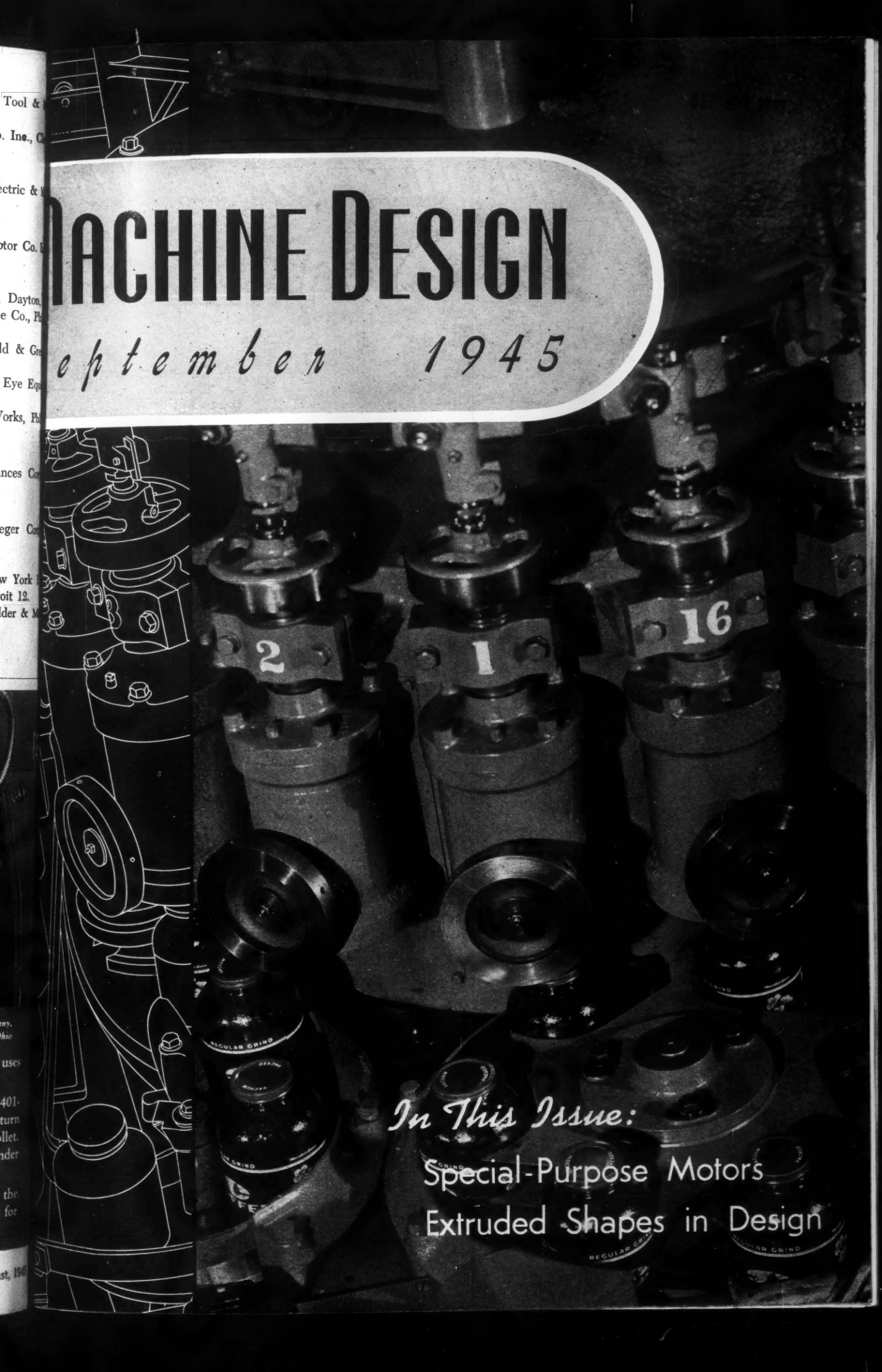
MACHINE DESIGN
September 1945
In This Issue:
Special-Purpose Motors
Extruded Shapes in Design

What do You Say, Doc?

THE "DOCTOR"—
McGarvey Eddleman of Allis-Chalmers Norwood Works—is taking a temperature reading during the heat-run test. It's just one precaution that helps Allis-Chalmers build consistently great motors.

NO—THAT'S NOT a sick mo
Actually it's a very *hea*
one. But that's something we m
know — through generous sam
testing — before Allis-Chalm
motors can tackle jobs for you.

Part of the "physical exam"
motor at the left must pass is
heat run test. Bristling with th
mometers, the motor runs at
load — and speed and tempera
are recorded for every hour.

Five or six hours can tell y
lot about a motor's characteris
—but it takes more like five or
years to tell you its *character.*

And it's the test of time in wh
Allis-Chalmers motors have es
lished that they are *great* mot
That's why you hear so many e
neers say: "You can depend
Allis-Chalmers Motors!"

• • •

If you could meet and talk with
men who build Allis-Chalmers
tors, you might be surprised to le
how keenly they are aware of
big *personal* stake they have
every motor they build for you.

They know that factory tests
fully pre-determine how well a m
tor is built *just don't exist;* th
there's still no substitute for resp
sible craftsmanship.

And they know that when th
build great motors for you they
making *friends*—and that no co
pany and its workers can have
many of them. ALLIS-CHALMER
MILWAUKEE 1, WIS.

YOU CAN DEPEND ON ALLIS-CHALMERS MOTORS

MACHINE DESIGN

THE PROFESSIONAL JOURNAL OF CHIEF ENGINEERS AND DESIGNERS

SEPTEMBER, 1945 Volume 17—Number 9

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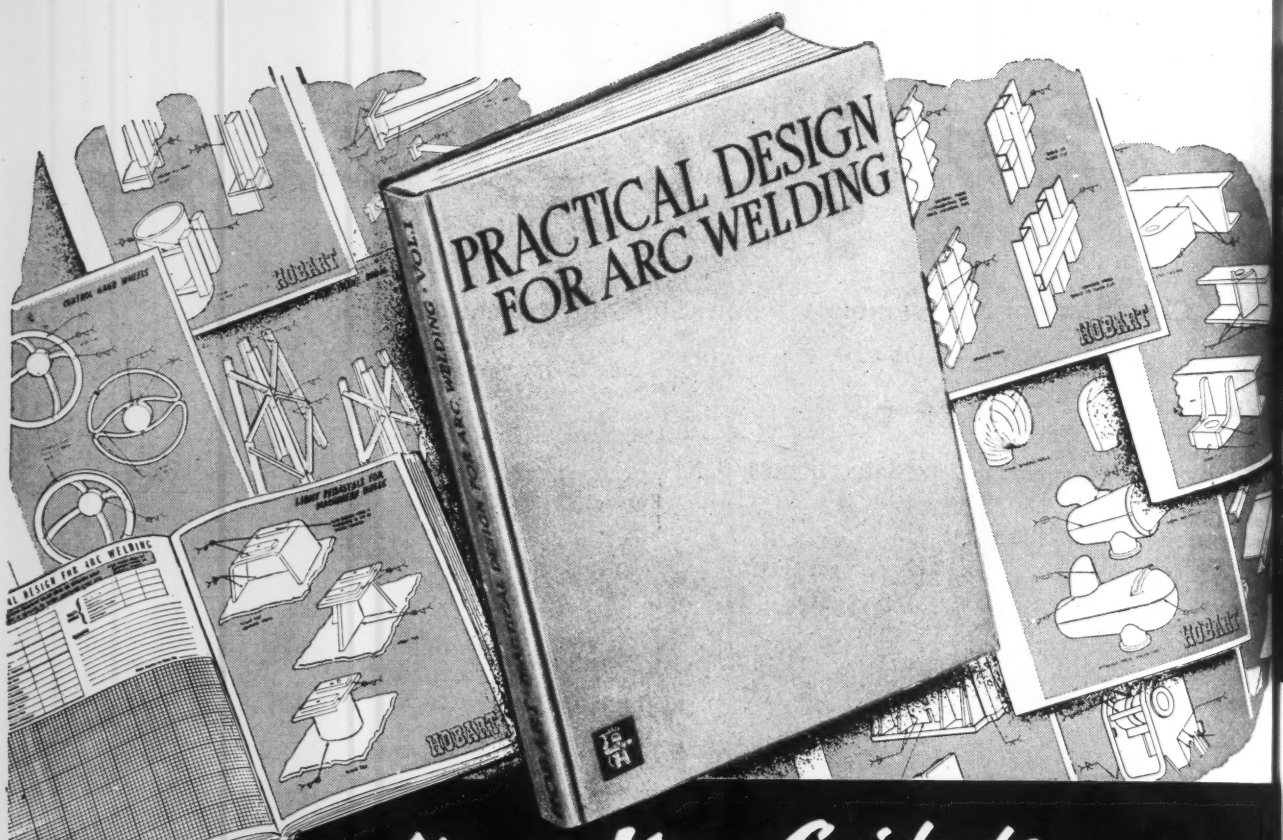

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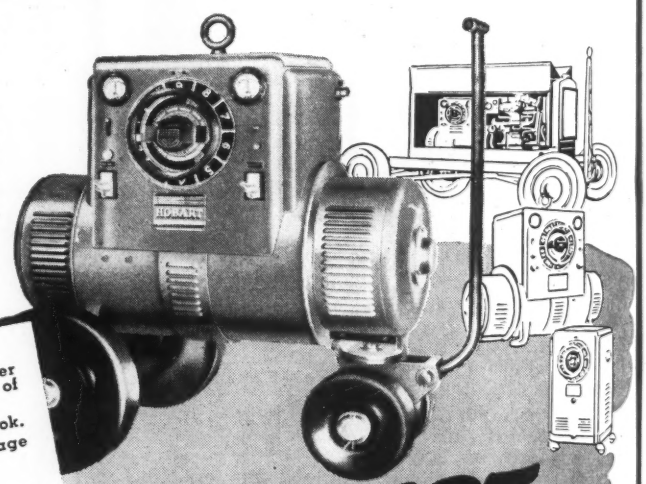

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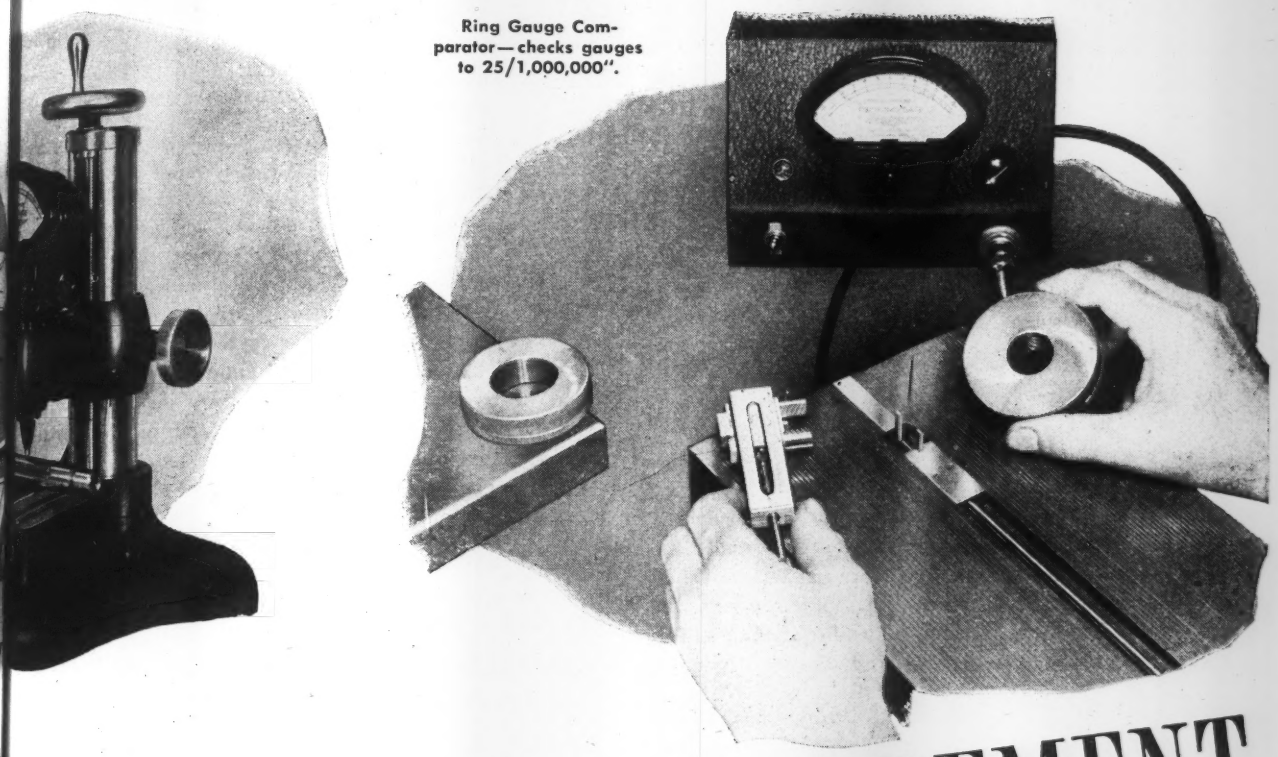

Ring Gauge Comparator—checks gauges to 25/1,000,000".

MIRACLES OF MEASUREMENT

from the magic tube of electronics

TODAY, fine manufacturing calls for working tolerances not of thousandths—but ten thousandths, hundred thousandths and even millionths of an inch! One of the secrets of Jack & Heintz low cost mass production of high precision equipment lies in the ingenious electronic measuring gauges used throughout the eight plants.

With one of these J&H-developed-and-built gauges even an inexperienced worker can make a complicated precision measurement in a second. For laboratory experiments, Jack & Heintz engineers have made an electronic gauge capable of measuring 2/1,000,000"! One of the shop gauges pictured is calibrated to 25/1,000,000; others in common use are measuring ten thousandths and hundred thousandths day in and day out.

While most of these gauges fall into the "special purpose" classification, they do have one thing in common. That is the basic electronic circuit system that makes them so highly accurate. This method of measurement is new and, as perfected by J&H engineers, has unlimited possibilities for use wherever exceptionally precise checking of parts must be done quickly.

Jack & Heintz has made effective use of these electronic devices to speed war production. They can be adapted to postwar production, too. Merely by changing the holding fixture on each gauge, the magic tube of electronics can be converted to speeding finer things for better, lower cost peacetime products.

If you have a measuring, checking, testing or production problem that calls for forward-seeing engineering such as this, get in touch with Jack & Heintz today!

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Topics

DEICING the wings of the C-82 Packet, the Army's new giant cargo plane, is accomplished by distributing hot air to all parts of the wings and to the tail assembly through a system of nonmetallic ducts. Travelling at high velocity the air dissipates its heat to the outer surfaces raising their temperature to 130 degrees. The air is heated from the engines' exhaust gases in a heat exchanger and carried under pressure to the duct system. Ducts are fire-resistant glass fabric combined with synthetic rubber and resins.

HIGH-IMPACT absorbing filament lamps have been developed to withstand violent physical shocks. The lamp has a rubber skirt between bulb and base which is sufficiently elastic to absorb shock yet rigid enough to prevent harmonic vibrations which might destroy the filament.

UNCOVERED from Germany's technical industrial secrets by investigations under the direction of the Joint Chiefs of Staff are the following: A plane with a ceiling several thousand feet higher than any American design; process for welding side seams on tin cans; new applications of radiation devices; new and improved X-ray tubes; new data and processes for synthetic rubber, high octane gas, plastics, petroleum products, and electrochemical products.

HELIUM instead of air has been successfully used to inflate large airplane tires, reducing plane weight. Chief objection to helium has been its rapid diffusion through rubber which has been overcome through the use of Butyl rubber tubes. Helium diffuses 2½ times faster than air through rubber but only one-fourth as fast as this through Butyl. Weight saved through the use of helium in each 110-inch tire is 79 pounds.

DOUBLE-BEAM cathode-ray tube now provides two complete "guns" in a single glass envelope, both aimed at or converging on a single screen for simultaneous and superimposed traces. Developed by Allen B. Du Mont Laboratories Inc., the tube provides complete and independent control of the three-axis functions for each beam. Heretofore, simultaneous comparison of two phenomena could only be made with two separate tubes or with an electronic switch to present first one phenomenon and then the other in rapid succession on the same screen.

RIVETING MACHINES set as many as 3000 rivets an hour. Inherent simplicity of this fastening method and the development of setting machines have extended the uses of riveting in aircraft mass-production methods, according to Curtiss-Wright Corp.

JET-PROPELLED German fighter planes, a study of a captured ship reveals, differ in several respects from our designs. The former utilize axial-flow compressors whereas ours have centrifugal compressors. Two jet engines, one in each wing, power the German type while our fighters have the power plant in the fuselage. Also the German planes have slots in the leading edges of both wings to increase rate of climb and reduce landing speed.

NEW RADAR altimeters, designed to indicate true height above terrain rather than altitude above sea level, weigh only 30 pounds. This equipment was made possible through an intensive development program which provided a sensational reduction in weight of about 70 pounds.

HOME FREEZERS with doors opening like a domestic refrigerator will "spill out" less "cold" than would be lost from top opening chests, according to Westinghouse tests. This is due chiefly to the fact that chest type units are open longer because it is necessary to remove and repack packages to obtain the ones desired. Also the heat absorbed by removed packages during the reshuffling is a contributing factor to the less economical operation of the chest types.

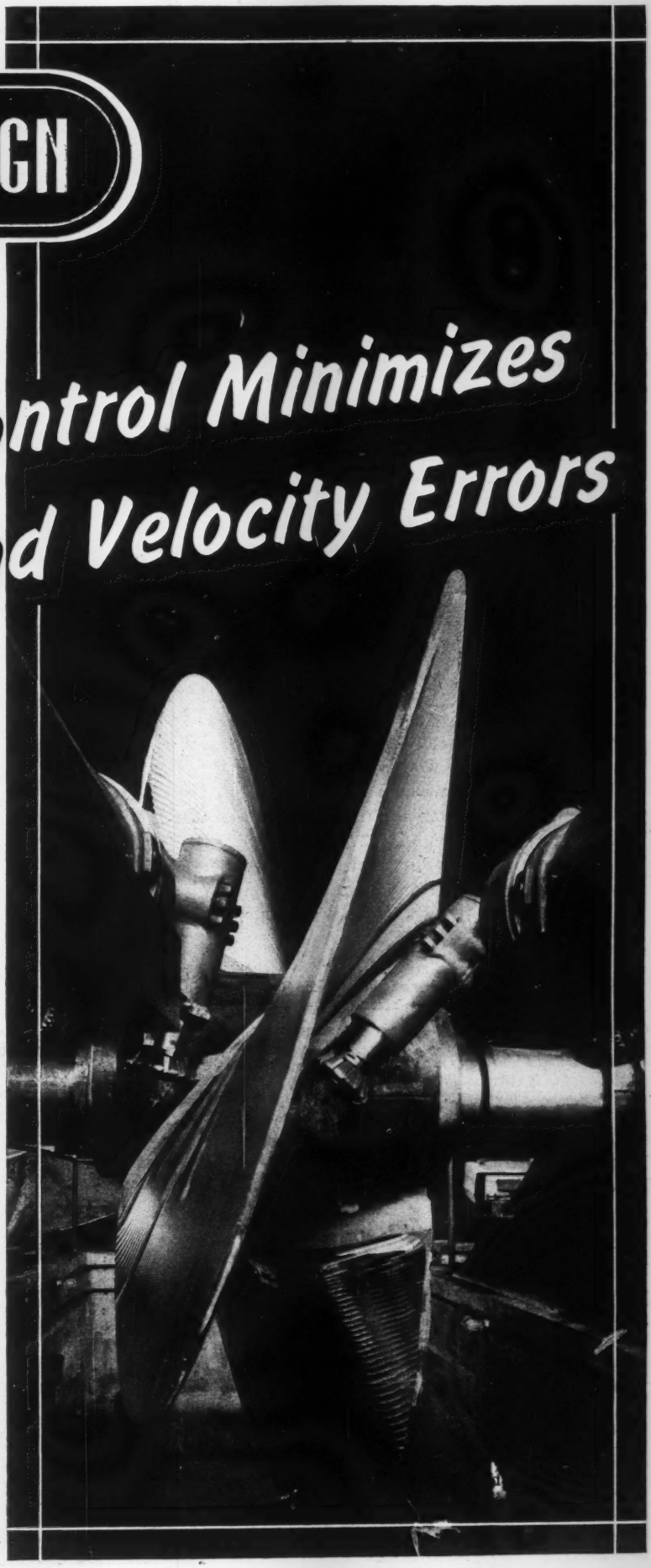
FIRST AWARD in a proposed nation-wide series for outstanding records of private industry for employment and training of veterans of World War II was received by Bell & Howell Co. The award was made jointly by the National Association of Personnel Directors and the national organization of Disabled American Veterans.

MACHINE DESIGN

Contour Control Minimizes Hunting and Velocity Errors

By Oren G. Rutemiller
Crosley Corp.

and H. Earl Morton
Morton Manufacturing Co.



WHEN THE problem of developing a machine for contour milling of ship propellers for the United States Navy was proposed, it was felt that the machine should have a constant feed in one direction and a superimposed, controlled infinitely-variable component with a direction normal to that of the continuous feed. Previously, duplication of machined parts from a model had been performed primarily on a type of machine whose feed was accomplished in small increments or steps.

Ideas formulated by the authors were pooled with those of the design and research engineers of Westinghouse. Then a general overall scheme was developed and, as the detailed design progressed, numerous conferences were held. Because elec-

Fig. 1—These cutters for profile milling are controlled by probes tracing over model

trical and mechanical design must be closely coordinated, no detail was considered finished until it was deemed satisfactory by both the electrical and mechanical engineers.

Built for the Navy and shown in *Figs.* 1 and 2, the machine simultaneously mills the suction-face side and pressure-face side of propellers having varying pitch and is a good example of the results attainable by closely coordinating the work of electrical and mechanical designers. Three motor-generator sets and eleven motors are utilized for various operations. All of the motors except one which drives the lubricating pump are flange mounted. Six operate in a definite automatic sequence when the machine is performing its normal cutting operation. A plan view of the machine, showing its design features and location of the drive motors, is illustrated in *Fig.* 3.

The machine is of the form following type, that is, the cutters are caused to follow the desired contour in response to a continuously-variable highly-sensitive servomechanism or position regulator that follows a scale model of the propeller. Only one blade of the propeller is represented by the two scale models, one for each face of the blade.

Two identical position regulators, each consisting of an adjustable-voltage drive in which the exciter is energized by an electronic amplifier, control the position of the cutter used on each face of the blade. A Silverstat (voltage regulator) mechanism, operated by a system of levers from a probe, is incorporated in the tracer head. A force of less than two pounds is exerted on the model by the tracer head. Therefore wood or plaster models may be used without rapid model wear. To compensate for the off-set of the cutting point from the center of rotation, the probe is a scale reproduction of the cutter. Utilization of the electronic amplifier facilitates the incorporation of anti-hunting and velocity-error correction means and permits the use of a small Silverstat and small resistors. This makes it possible to build the entire control unit into the tra head and thus avoid a large number of flexible conn tions to the tracer head.

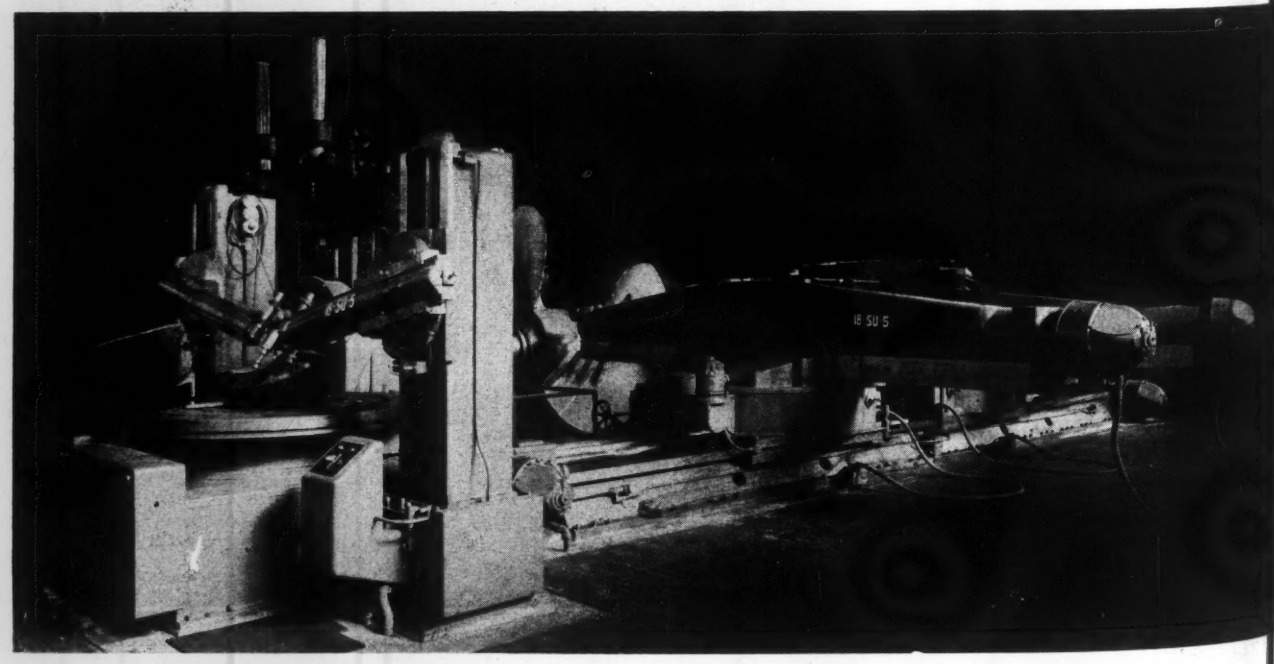
Consisting of a single-stage electronic power unit, amplifier employs three Type 6L6 tubes in multiple. T improves reliability since the unit will operate on only of the tubes. Also, these tubes are easy to procure beca they are a popular radio type.

Utilizes Duplicate Controls

In *Fig.* 4 is shown a schematic diagram of the posit regulator mechanism. Only one of the two units is ill trated and the gearing is rearranged for simplicity. Wh the machine is set up, the tracer probe and the cutter a positioned accurately at the same relative point on t model and the propeller blade, respectively. The trac saddle is moved in relation by its drive screw until t tracer Silverstat is in the midposition corresponding zero speed on the saddle-feed motor. The saddle-fe motor is then energized, placing it under full control the tracer. As the model table and work rotate, the mo moves relative to the tracer and the tracer probe is d flected as it passes over the face of the model. This caus the Silverstat to be deflected from its neutral position a results in a consequent change in the input voltage to t amplifier which produces a corresponding change in t voltage applied to the saddle-feed motor. This causes t cutter saddle and the tracer saddle to move in the directi to return the tracer probe to its original position. Err are minimized and hunting prevented by the application acceleration components to the amplifier input and by feedback arrangement.

It can be seen from the foregoing that the regulati system is dormant except when its quiescence is disturb by a movement of the tracer probe. The model and wo are rotated in synchronism by the work-arbor drive mot Since this motion is the master of all movement involve its drive is of particular importance. This drive must p

Fig. 2—Profile milling machine. Models on table in left foreground position the probes which, through electronic circuits, control machining operations



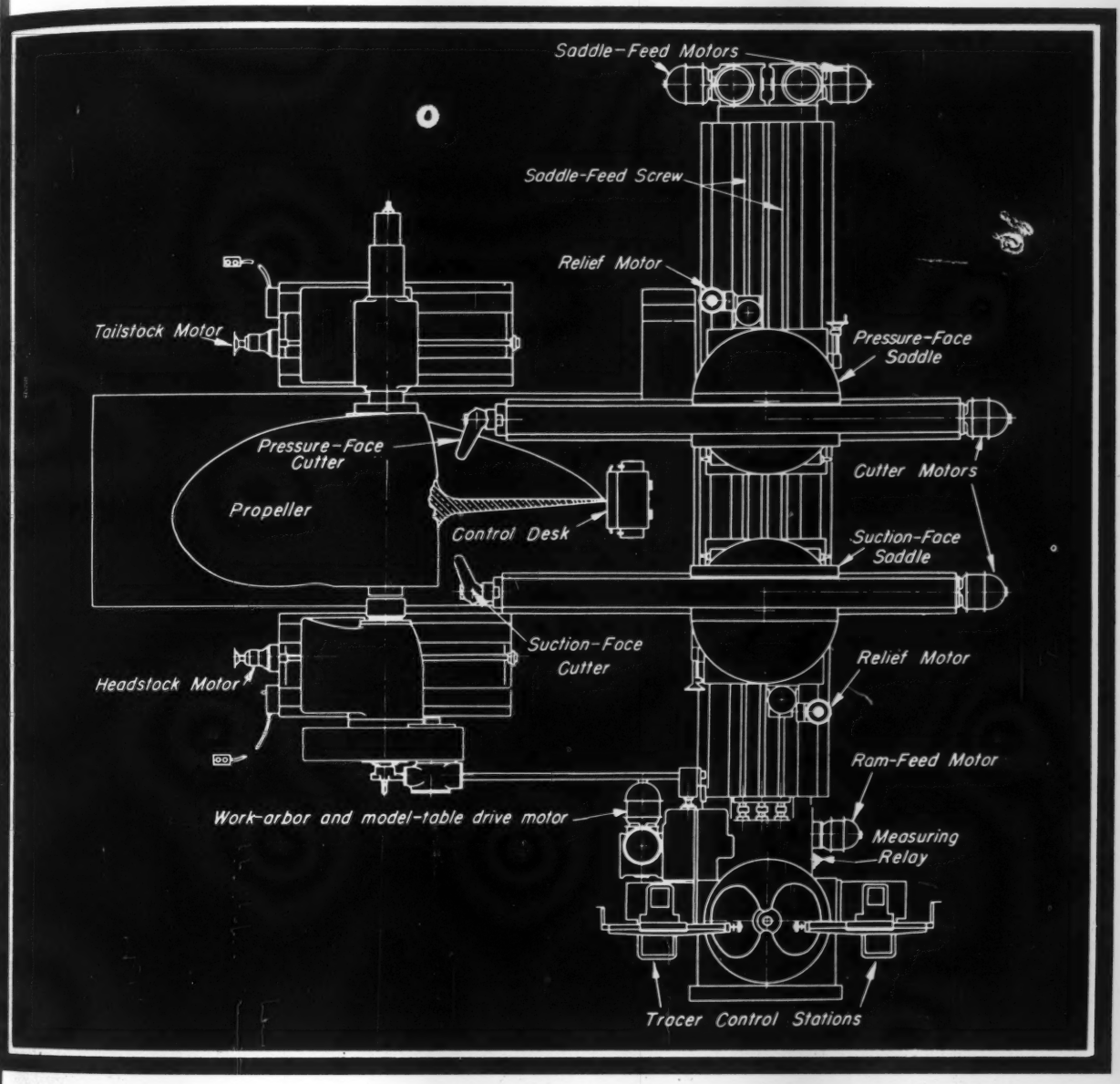


Fig. 3—Plan view showing motor drives for various motions and model table with contour controls

le a wide speed range together with controlled acceleration and retardation in order to limit the accelerations to tes that the position regulators can follow. The work-bor drive is a Rototrol-regulated, adjustable-voltage ive. Its speed is controlled by a motor-operated rheo-t driven by an adjustable-speed motor—to provide con-olled rates of acceleration and retardation. There are finite limits to the speed at which the position regulator n follow with the required accuracy. Consequently, the rk-arbor drive is equipped with a second regulating sys-m that controls the work-arbor motor speed in order to intain the desired saddle-feed speed. Another regulating stem affects the work-arbor motor in response to cutter ad so as to maintain a cutting speed that is within the ility of the cutter. Limits of the cutter load and saddle eed are adjustable by rheostats on the operator's con-l desk.

Cutting takes place in only one direction of rotation of e work in order to keep all backlash and deflection in one rection thus improving the accuracy of the machine. The fter saddles are provided with a relieving mechanism that moves them with respect to their driving nuts, thereby moving the cutter relative to the work. These mechanisms move the cutters into position for a cut stroke and away from the work during the return stroke. Since no cutting takes place during the return stroke, much higher speeds can be utilized because greater form following errors can be tolerated.

Relief Motors Start Cutting Cycle

In operating the machine, both position regulators are adjusted to the neutral position and the automatic cutting cycle is started. Depressing the automatic-cycle start button causes the relieving motors to bring the cutters into cutting position. As these motors drive the saddles against positive stops, they stall, and are then de-energized by time-delay relays. The relieving mechanism operates a limit switch when it arrives at the cutting position. Operation of this switch causes the work-arbor motor to start

in the cutting direction at its minimum speed. The motor-operated rheostat starts and the work-arbor motor is accelerated at a rate determined by the speed of the rheostat motor.

Movement of the model table causes the saddle-feed motor to start under control of the tracer as previously discussed. When the tracer motor has accelerated to the preset speed determined by the setting of the operator's control rheostats, the rheostat motor stops. If the contour of the model is such that the saddle-motor speed changes appreciably from this setting, the secondary regulating system starts the motor-operated rheostat in the correct direction to increase or decrease the speed as may be required to maintain the desired saddle speed.

Adjusts Load Automatically

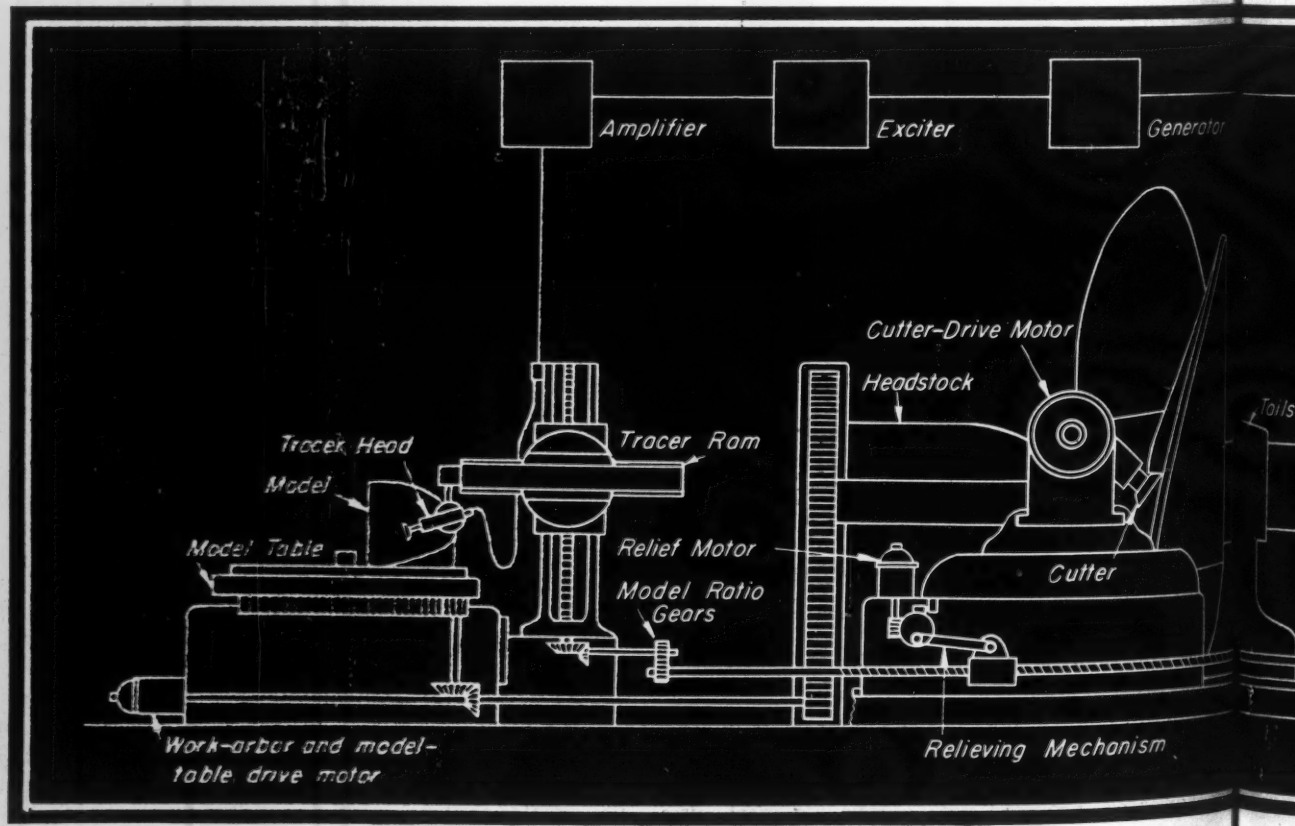
Should the cutter load increase beyond the desired maximum because of irregularities in the work, the work-arbor speed is adjusted to reduce the cutter load automatically by the motor-operated rheostat.

Thus the cutting operation proceeds until a limit switch is operated by a dog on the model table as the cut approaches the end of the blade. This starts the motor-operated rheostat in the direction to decrease speed thus retarding the work-arbor motor. When the rheostat reaches the minimum speed position, the work arbor is stopped and the relieving mechanisms operate to move the cutter away from the work. After the relief is completed the work-arbor motor is started in the reverse direction with acceleration again controlled by the motor-operated rheostat. During the return stroke, the ram-feed motor is started. This motor drives the cutter and tracer rams forward so as to place the cutter in a new path preparation for the next cutting stroke. The ram feed crement is controlled by a Morton measuring relay.

The control cubicle containing all electrical and m netic control equipment is shown in *Fig.* 5. The electro amplifier is at the upper left and the motor-operated r stat is at the upper right. The remaining panels con the relays and contactors necessary for automatic ope tion of the other motors. One of the exciter motor-gene tor sets may be seen on the floor of the cubicle. T operator's control desk is in the foreground. This cont desk is located on a balcony at the head of the propel pit from which point the operator can watch the ent cutting operation. All operation may be controlled fr this desk. The rheostats on the front of the desk cont the cutter-motor speed. The instruments indicate cutt motor load and saddle speed. Two portable pushbutt stations, normally attached to the side of the cont desk by hangars, are provided for setting-up purposes.

The cutter heads have 360 degrees of freedom in t planes and may therefore be adjusted to any desired c ting angle. Some propellers have overlapping blad consequently there is little room for cutting heads wh working at the root of the blade. Because of this th was not sufficient room for the cutter drive motors a the necessary gear reducers at the front end of the r The gear reducer is mounted inside the ram itself and t drive motor is flange mounted on the back end of t ram, *Fig.* 3. A shaft through the center of the ram dri the cutter reducer. Flange-mounted motors are almost necessity for such an arrangement. They are accessi

Fig. 4—Schematic arrangement of position regula mechanism. Because both pressure face and suct face units are similar, one only is shown



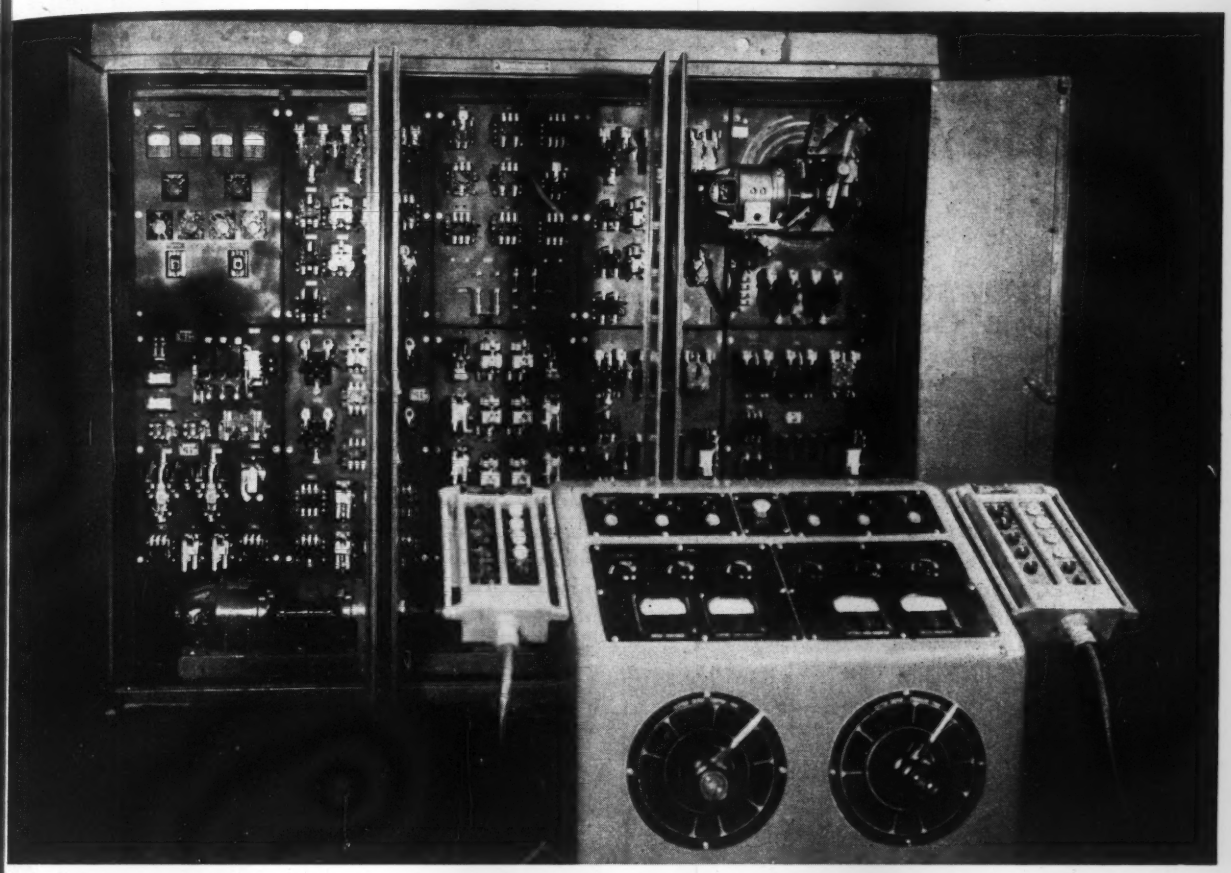
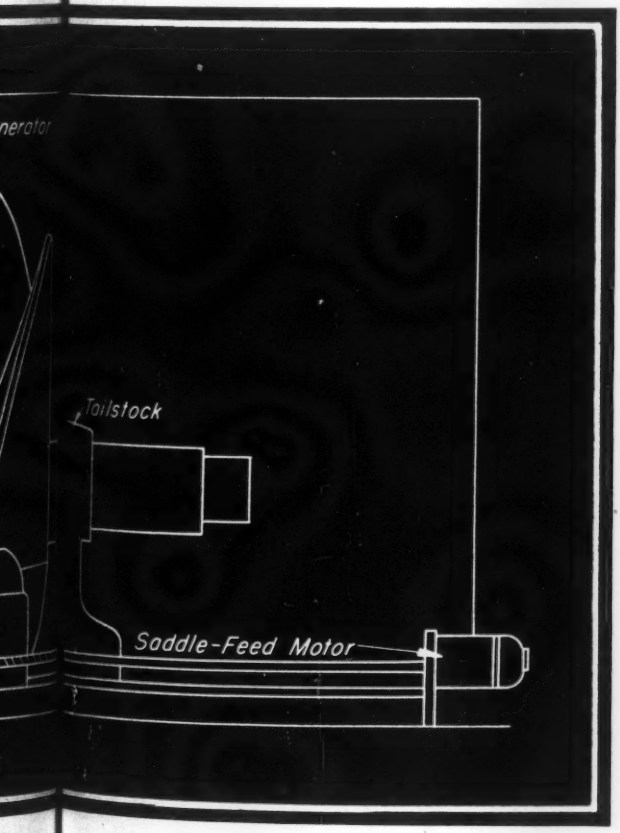


Fig. 5—Above—Control cubicle and control desk contains all the equipment necessary for automatic operation of the motor drives



for servicing, adequately ventilated, and completely free of any chips.

The relieving drive motors are vertically mounted. Therefore flange mountings were selected, obviating the need for special brackets or castings generally required for vertical foot mounting. The saddle-feed motors and the arbor-feed motors are built integral with their gear housings. They and the ram-feed motor are flange mounted to avoid the necessity of separate mounting plates on the machine foundations and to provide perfect alignment at all times.

Headstock and tailstock adjusting drives employ flange-mounted gearmotors, that is, integral gear units with the motor frame mounted to the gear case. The adjusting screw is solidly coupled to the output shaft of the gear unit. Thus this unit forms one bearing for the screw. The gearmotors are equipped with high-torque intermittently rated hoist type motors. Front shaft extensions are furnished on the motors for mounting a handwheel with an integral clutch to provide a means of manual adjustment.

Gearmotors of this type usually are equipped with round frame motors without feet, the unit being mounted from suitable feet or a flange on the gear case. Standard motor frames with feet, however, are utilized on this unit. The motor frame is rotated as for side-wall mounting, that is, wth the bottom of the motor feet in a vertical plane. The reversing magnetic controllers are mounted to the motor feet. Pushbuttons are on flexible cables.

By this design the entire drive, motor control, and necessary gearing is a unit made from standard parts supplied by the electrical manufacturer, eliminating the necessity of many special parts.

What's Behind the Atomic Bomb?

PRIOR to the atomic bomb two principles—conservation of mass and conservation of energy—were the cornerstones of modern science. However, in developing the theory of relativity Einstein concluded that mass and energy must be interchangeable and related by the equation $E=mc^2$, where E is the energy, m the mass and c the velocity of light. This means that if a pound of material could be completely converted into energy, 11.3 billion kilowatt-hours would be realized—equivalent to the entire output of this country's electric power industry for a month. While no such fantastic result has even been approached in practice, in the atomic bomb there has been accomplished for the first time an appreciable conversion of mass into energy.

To understand the splitting of the atom it is necessary to consider the salient features of atomic structure. Heart of the atom is the nucleus, a closely packed group of neutrons (electrically neutral particles) and protons (positively charged particles) containing nearly the whole mass of the atom. Surrounding the nucleus is an empty space, about 10,000 times the diameter of the nucleus, in which electrons (negatively charged particles) move like planets around the sun. Chemical reactions such as combustion of fuels or explosion of TNT involve only the electrons, whose mass is a trifling proportion of the whole atom.

DESIGN and production details of the atomic bomb still are top secrets. However, in a War Department report Prof. H. D. Smyth, consultant on the project, reveals much of the background, and the accompanying notes are based on this report. Before atomic power becomes feasible for industrial purposes, the nuclear chain reaction must be made to occur slower than in the bomb but fast enough to produce sufficiently high temperatures for good thermal efficiency

Because the mass of the nucleus is relatively so much greater, it is obvious that reactions involving conversion of even a small fraction of the mass of the nucleus are a potential source of tremendous power—what we know as atomic energy. The neutrons and protons in the nucleus are subject to two kinds of forces—attraction of all particles (the same force as gravitation) and electrical repulsion of the positive charges on the protons. In most elements these forces are in stable equilibrium, but certain combinations of neutrons and protons are unstable, particularly the large nuclei. Elements with unstable nuclei are called radioactive and constantly emit portions of their nuclei (alpha particles) or electrons (beta particles) as well as electromagnetic radiation (gamma rays). Such a material is uranium which consists approximately of 99.3 per cent uranium 238 (atomic weight 238) and 0.7 per cent uranium 235. While both kinds of uranium (called isotopes) are radioactive, U235 is enormously more so and is the key to the atomic bomb.

When splitting or "fission" of U235 occurs the products contain less mass than was contained in the neutrons and protons comprising the original nucleus, and it is this energy corresponding to the mass difference that is the source of atomic power. While the unstable U235 nucleus may disintegrate spontaneously, ordinarily it is set off by some agent such as a neutron, proton, alpha particle, or gamma ray. By far the most effective missile is the neutron which, having no electrical charge, is not easily deflected from its course by other particles. If one neutron causes a fission that produces more than one new neutron the rate of reaction may accelerate, depending upon how many of the new neutrons cause splitting of other U235 nuclei. To cause the chain reaction necessary for the production of explosive power, the escape of neutrons must be reduced to a minimum.

Proportion of neutrons that escape to the surrounding depends on the size of the lump of material. Below a certain critical size the ratio escaping due to the high proportion of surface to volume is so great that the reaction fizzles out. Above that size relatively few neutrons escape and the chain reaction occurs. Herein lies the clue to the detonation of the bomb. By constructing the bomb with several subcritical size pieces which can at the desired moment be united into one mass larger than the critical, the release of destructive energy by chain reaction can be timed. Probability of fission is greatly increased by use of a "moderator" such as carbon or "heavy" water which slows down the excessive speed of the neutrons produced by fission.

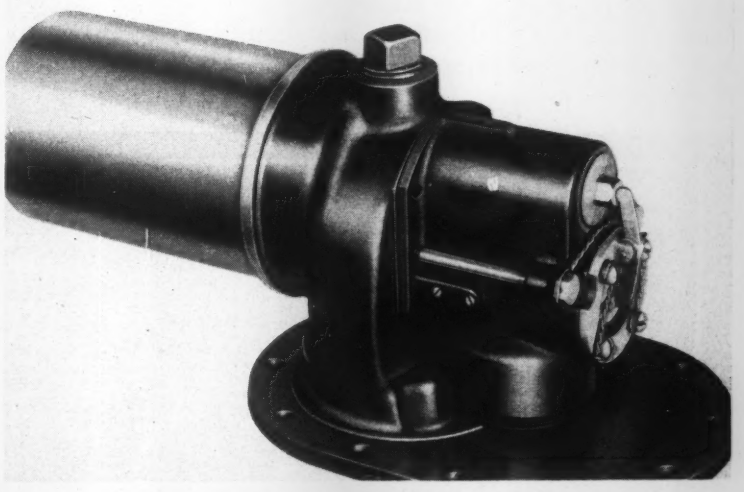
Inasmuch as only 0.7 per cent of natural uranium is U235, a major development was the separation of U235 from U238. However, when the neutrons emitted by U235 bombard the U238 nucleus a new element, plutonium, is produced which has a radioactivity comparable to that of U235 and is entirely suitable for use in atomic bombs. Plutonium production by this means, and its separation from uranium, constituted another major development.

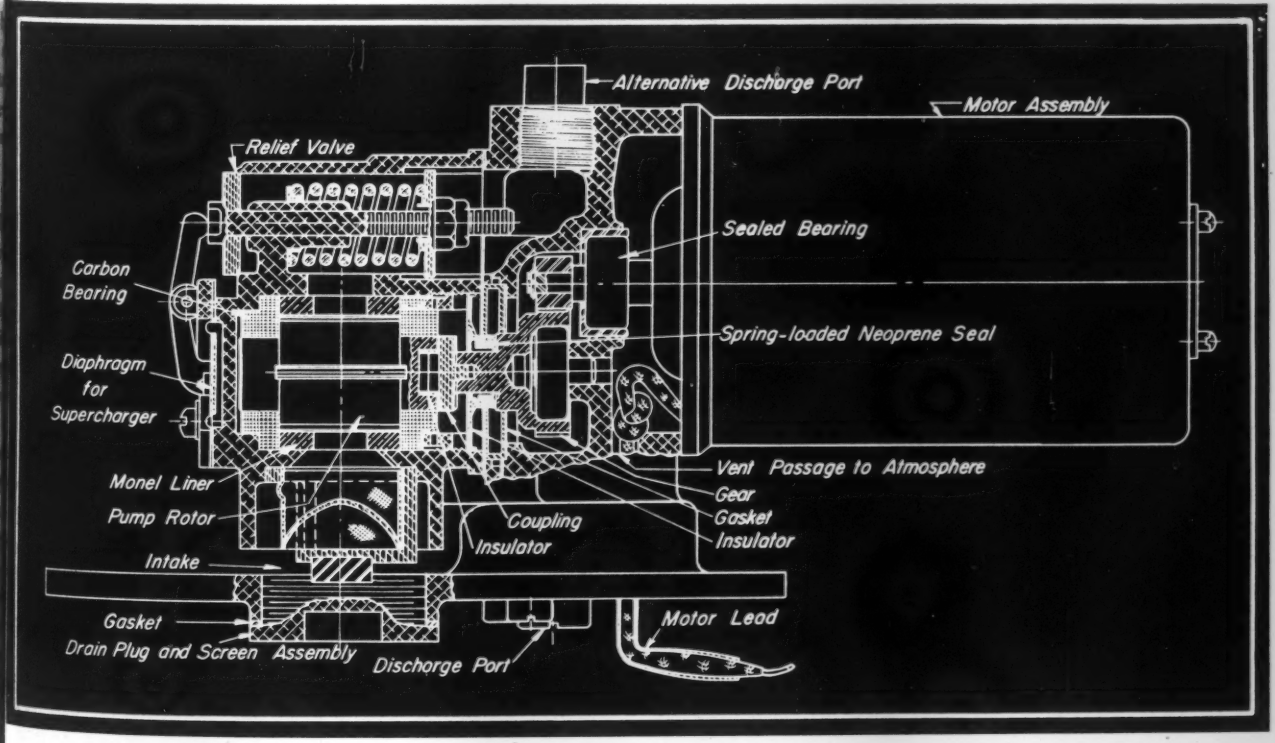
Main problem in the design of the bomb was to insure that the nuclear chain reaction would be substantially completed before the bomb itself flew apart. Use of a "tamper" or envelope of dense material, by virtue of its inertia, delays the expansion and gives time for the completion of the chain. It was also essential to bring together all the subcritical masses fast enough to prevent premature detonation before the bomb had reached its most compact form. By shooting one part as a projectile against another, sudden and perfect contact is obtained.

Scanning THE FIELD for Ideas

Total immersion of water-alcohol injection pumps on B-29 Superfortresses simplifies installation and requires no external room for mounting, protecting the equipment from possible damage. Designed by Romec Pump Co., the entire unit including pressure regulating and relief valve, motor, electrical connections, discharge port, vent, drains and supercharger connection is assembled on a flange mounting. When the unit is inserted in the tank opening, gasketed and bolted on, all connections are available in the bottom of the flange, facilitating installation and maintenance.

Corrosion by galvanic action is obvi-

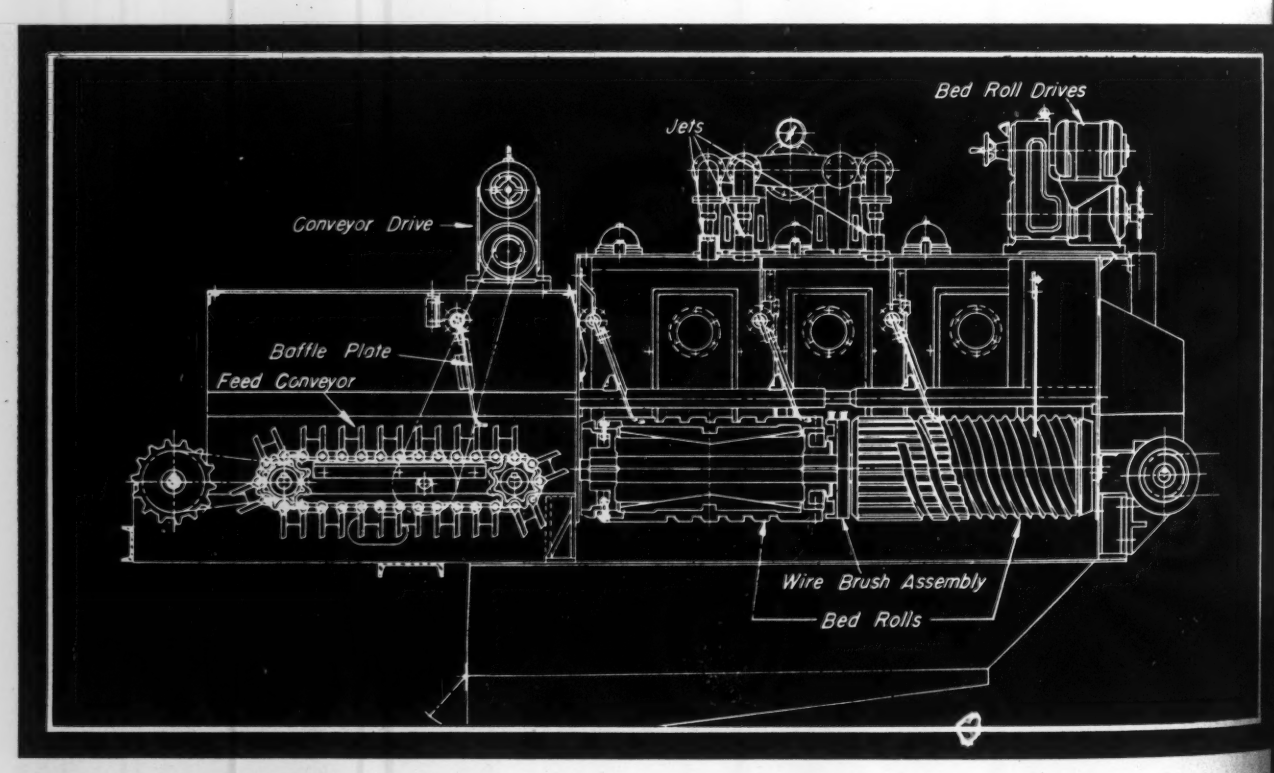




ated by insulating the pump parts from each other with nonconducting materials so that the water cannot act as an electrolyte. Monel liner, pump blades and carbon bearings are thus insulated from the aluminum pump housing. The motor likewise is fully insulated from the pump housing with O-ring rubber gaskets. Insulation is also used for the valve guide, valve seat, seal spring and other parts where dissimilar materials might set up a battery action resulting in corrosion. Motor parts operate in air at atmospheric pressure and therefore require no corrosion protection. Gear drive for the pump rotor is lubrication packed, sealed from the pump rotor by a finger-spring-loaded neoprene seal and from the motor by a sealed bearing.

Enclosed in a watertight housing the motor is vented to the atmosphere through an explosion-proof breather plug. Two O-ring rubber gaskets are utilized to seal the motor, one between the bolted assembly of the motor and pump body and one between the motor flange and stamped shell which is assembled to the motor by two bolts shown in the drawing. A filter is utilized on the motor to stop radio interference, holding it below a level of 50 microvolts. Design of pump allows to pull within a half-inch of the bottom of the tank as indicated in the sectional drawing. A supercharger connection, also in the flange, leads through a passage to a chamber behind a diaphragm. Supercharger pressure on this diaphragm increases the pump delivery proportionally through a linkage, shown in the drawing, by increasing the relief valve pressure. Drain plug and screen are a subassembly, facilitating cleaning of screen.

Weighing 6¼ pounds each, four pumps are used on a B-29, one for each engine. The entire system including 4 tanks and 40 gallons of water and alcohol weighs 700 pounds and, according to the Modification Center at Denver, increases the horsepower of a Superfortress by more than 10 per cent. It is expected that similar power increase may be effected for cargo planes, trucks and busses.

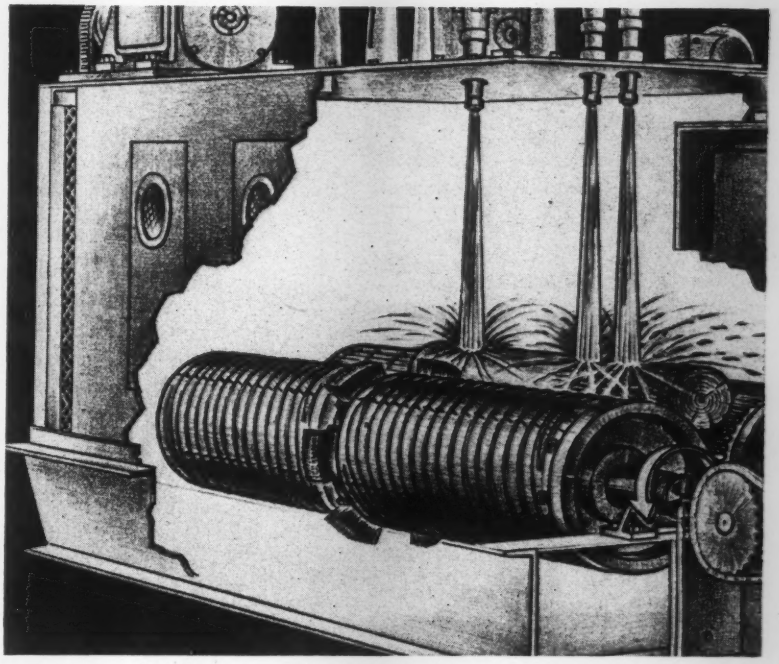


Barking of logs in a revolutionary machine is making possible badly needed increase in paper production of United States mills. The machine, designed by Allis-Chalmers, is unique in that its operation depends on effective direction of water jets which strip bark from the logs by erosive action. A sectional view of the machine is shown above and a sketch of the principle of operation at top of next page. In this machine three jets of water, two bed rolls and a set of six wire brushes shear the logs of bark, dirt and fungus growth without "end brooming the logs."

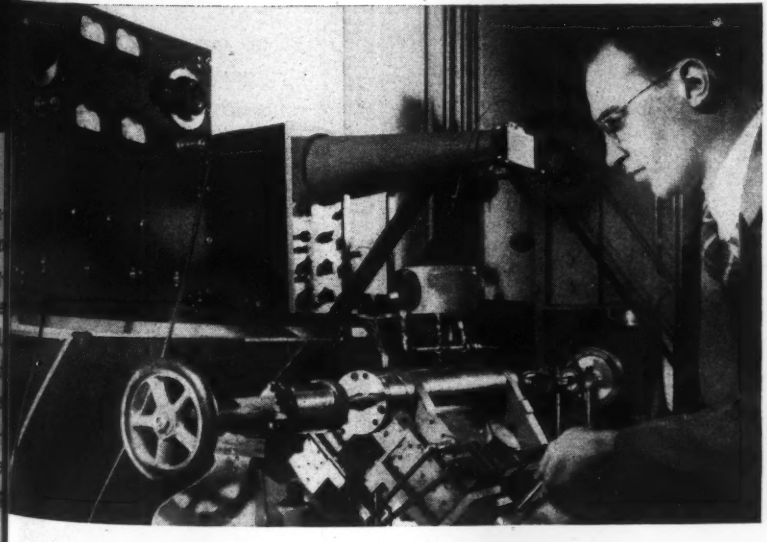
Logs fed into the intake by a conveyor are centered by a wing type bed chain and are held in position in the bed-roll crotch by three spring-loaded baffle plates which prevent rotation. The logs then pass to the two bed rolls—one fluted, the other spirally threaded—which rotate them and move them forward. Each bed roll as well as the front feed chain are driven by independent 7½ horsepower variable-speed motors. By varying the differential of roll speeds, maximum debarking

quality and machine capacity can be acquired for any class of wood. Jet nozzles are a specially-designed elliptical shape for concentrated force. Water for the three jets is supplied by a high-head four-stage centrifugal pump delivering 600 gallons per minute at 650 pounds per square inch pressure. Bark, waste water and dirt drop into a welded steel water hopper and sluice.

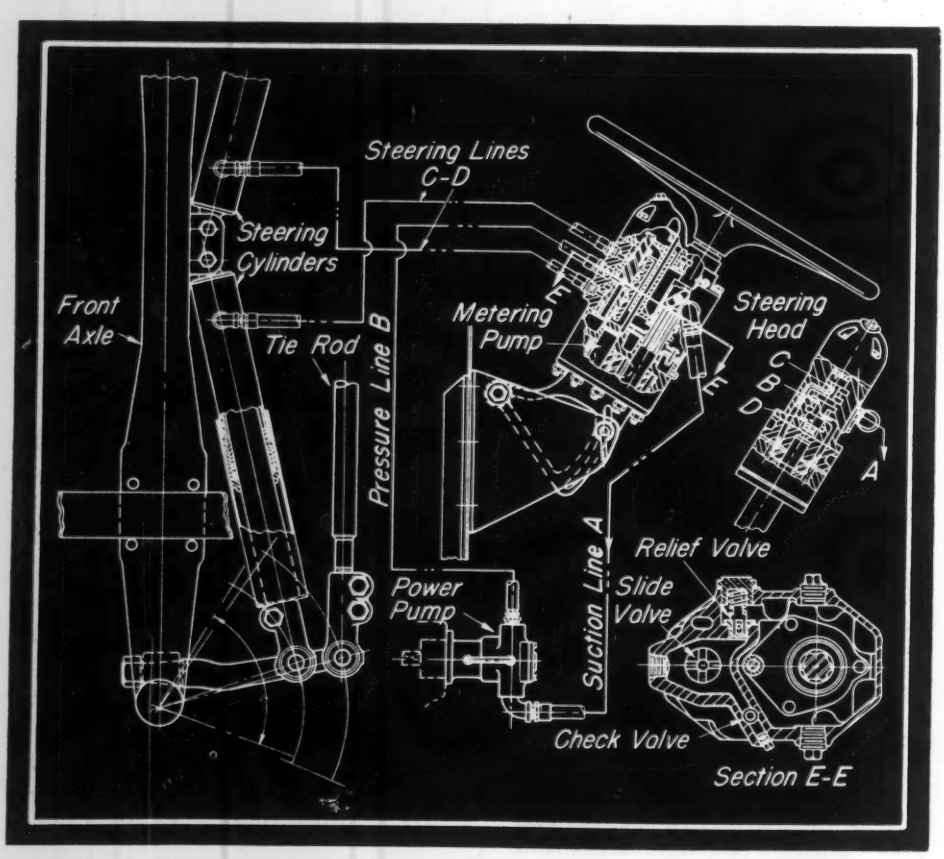
Constructed of heavy, welded-steel plate and rigidly reinforced structural steel, the machine can be knocked down easily for moving. Watertight doors are built into the sides of the housing for quick access to inside working parts. Waterproof floodlights illuminate the interior so that the entire operation is visible through protected glass windows.



Furnace-brazed assemblies for standard cam followers effect a savings of thirteen cents per part over machining from solid steel bar stock at The Glenn L. Martin Co. The assembled part consists of a rectangular flange with small tubular projections at each side from the center hole of the flange. As shown in the photograph at right, the cylindrical portion is stock steel tubing, sized to the proper diameter and cut off in a screw machine. The rectangular flanged portion is blanked, pierced and sized from steel stock by a progressive die. Copper brazing rings on the assembled parts are brazed in an electric furnace. After brazing two attaching holes are drilled and burred, the flange portion profiled by milling and the edge hardened by induction heating.



Measurement of movements or changes in position within one-tenth of a millionth inch may be made with the electrical micrometer, left. This instrument utilizes the principle of static - free frequency modulation radio to measure the position of either slowly or rapidly moving objects without touching the object being measured and has been utilized in several important war investigations. In the photograph the micrometer developed by the Battelle Memorial Institute as a research tool, is being employed for measuring the errors in a high-precision lathe spindle. Another appli-



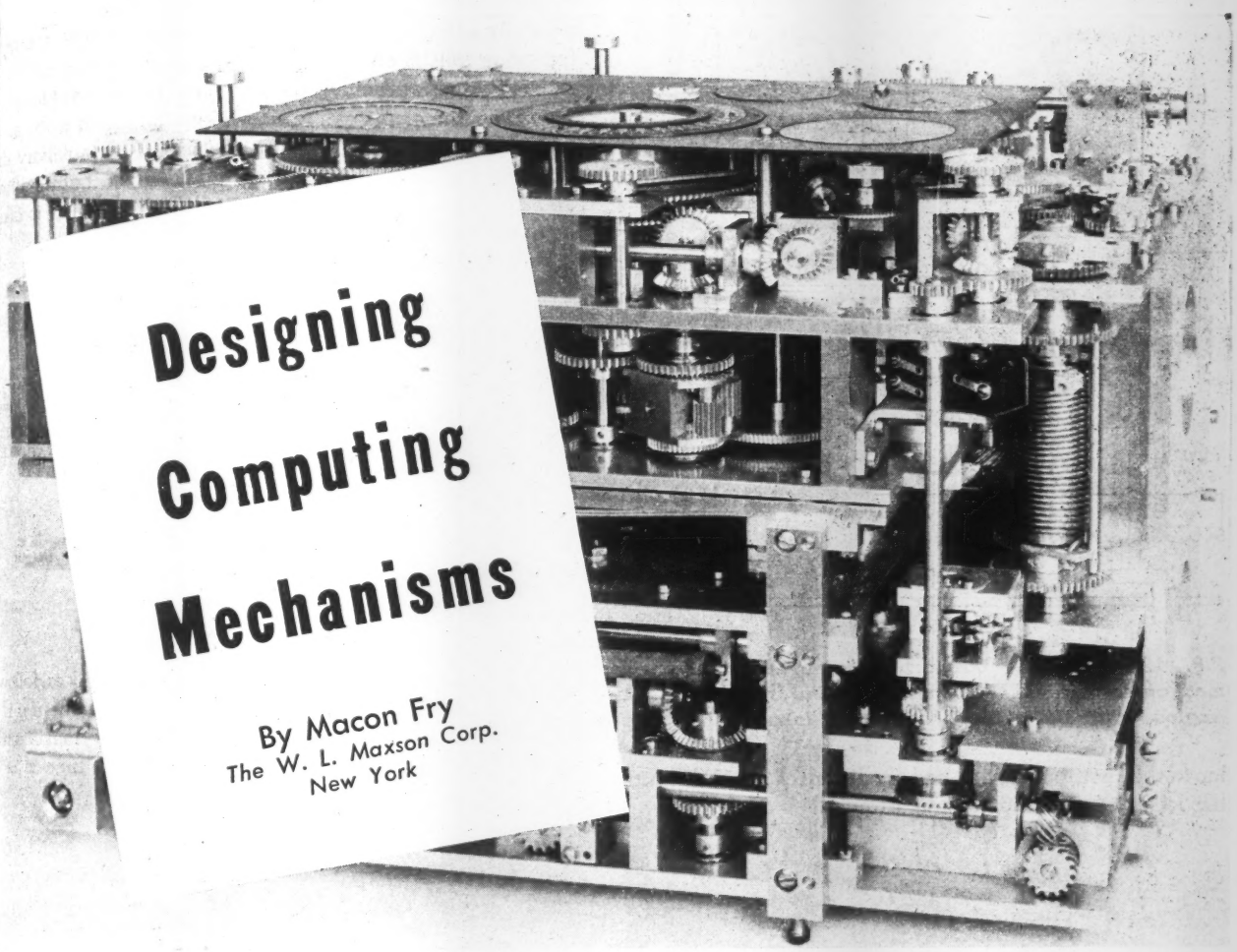
cation is for measuring and recor ing the changes in crystal structu when steel is heated rapidly.

Constant-ratio hydraulic stee ing mechanism provides easy stee ing of heavy vehicles, allowing th use of big simple tires rather tha the many smaller ones used on mul tiple wheels. Designed by Henr French, engineer for the Heil Co the elements of the system ar shown in section in the drawing be low and applied to a heavy earth moving vehicle at left.

No mechanical connections ar employed between the steering wheel and the axles. The steering head, to which the steering whee is attached, contains a steering drive metering pump, steering valve, re lief valve, check valve and oil res ervoir. From the oil reservoir in the steering head, the oil is drawn through a suction line to an engine driven hydraulic pump.

The steering wheel serves merely as the hydraulic control for the power steer. When the steering wheel is turned to the right, the pump forces oil into the left-hand cylinder causing right-hand steer ing movement. For a left-hand turn the pressure is on the right-hand cyl inder. Front wheels of the vehicle will remain in a locked position until the steering wheel is turned to allow a flow of oil in either direction. The metering pump gives a constant ratio between steering wheel movement and vehicle front wheel movement.

Should the power-driven pump ever fail, the metering pump automat ically becomes the power pump, and draws oil through the check valve from the oil reservoir and forces it into the steering cylinders by manual ef fort of the steering wheel.



Designing Computing Mechanisms

By Macon Fry
The W. L. Maxson Corp.
New York

Part II—Multiplying and Dividing

NEAR-MIRACLES accomplished by the mechanical brains which direct the fire of modern guns have been so impressive that these mechanisms have come to be regarded as something altogether "out of this world". Clever and ingenious as they are, however, close analysis shows them to consist of certain basic elements which by themselves are readily understandable. These elements and their present application to continuous computers are the subject of this series of articles, which is presented in the belief that designers of other machines and control equipment will find new uses for such mechanisms

BASIC elements of continuous computing mechanisms were discussed in last month's article of this series, and their application to addition and subtraction ustrated. In the present article methods of performing ultiplication and division ill be covered and the andling of trigonometric nctions discussed.

Multiplication of two variables

$$z = xy$$

ay be performed by any e of a number of mechanms, including the proporonal movement multiplier, e sector type multiplier, the ear cam — quarter squares ultiplier, and the logarithic multiplier. These will be scussed in detail in the folwing.

PROPORTIONAL MOVEMENT ULTIPLIER: This type of multiplier is shown in *Figs.* 12 and 13. *Fig.* 12 demonstrates the theory, which is based upon the fact that the corresponding sides of similar triangles are proportional. Input x crosspiece is positioned by a double leadscrew so that it moves in a direction at right angles to the guide rail carrying input y slide. A pin extends through slots in x crosspiece and the arm pivoted to y slide, and is located by their intersection. This pin engages a slot in output z slide. A fixed pin, located at a definite unit distance D from the guide rail carrying y slide, works in a slot in the arm of y. Thus the movement of input y sets up a right triangle having distance y and the unit distance D to the fixed pin as its two legs. Output z slide is constrained by a guide rail to move parallel to slide y by an amount determined by the pin extending through the intersection of crosspiece x and the arm of y. Consequently it sets up a second right triangle simi-

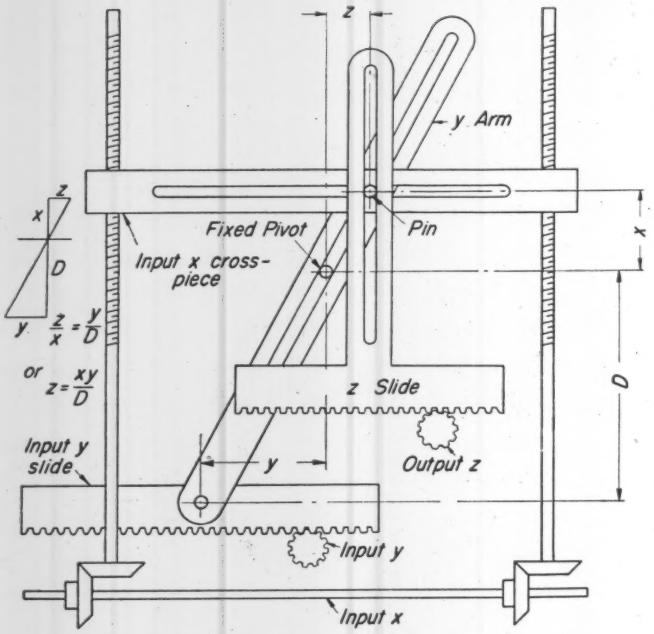


Fig. 12 — Above — Proportional movement multiplier mechanism, which sets up two similar right-angled triangles with sides proportional to inputs and output

lar to the first, but having as legs distances z and x. Putting the ratios of corresponding sides equal

$$\frac{z}{x}=\frac{y}{D}$$

or

$$z=\frac{xy}{D}$$

Taking D as the unit of measurement

$$z=xy$$

In *Fig.* 13 is shown the construction of this multiplier. Note the method of carrying the slides in the guide rails. The slide has three rollers, two of which run in a slot on one face of the rail, and the third bears on the other face. The rollers are mounted on eccentric studs, so that lost motion between the slide and rail can be reduced to a minimum and the correct mesh obtained between the rack teeth and the pinion. The bushing on the arm of the y slide which receives the pivot is also eccentric, so that distance D may be adjusted accurately. The pin connecting the three members is mounted on a crosshead on the y arm, which is lowermost, and extends through two similar crossheads on the other two members.

If both input quantities may go both positive and negative, the fixed pivot must be located in the center of the system, as in *Fig.* 12. It frequently happens that one quantity will never have a negative value, in which case the fixed pivot may be located at the top, which will permit either reducing the size or doubling the scale of x, as desired. If neither input goes negative, the fixed pivot may be located in an upper corner, with further reduction in size or improvement of the scale.

Sector Type Multiplier: This type of multiplier, *Fig.* 14, is a modification of the proportional movement multiplier. By using sector arms and a four-bar linkage, the need for guide rails is obviated, but the computation is not theoretically exact and one input can have positive values only. However, the errors can be made small enough to be satisfactory in most cases, and by the use of an auxiliary differential both variables can be made to go both positive and negative. Referring to *Fig.* 14, if radius arm D is taken as unity, the law of this multiplier is:

$$\sin z = x \sin y$$

or

$$z = \sin^{-1}(x \sin y)$$

The difference between this value and the desired value $(z=xy)$ is quite small as long as the maximum value of y is below about 30°, as may be seen from the following table:

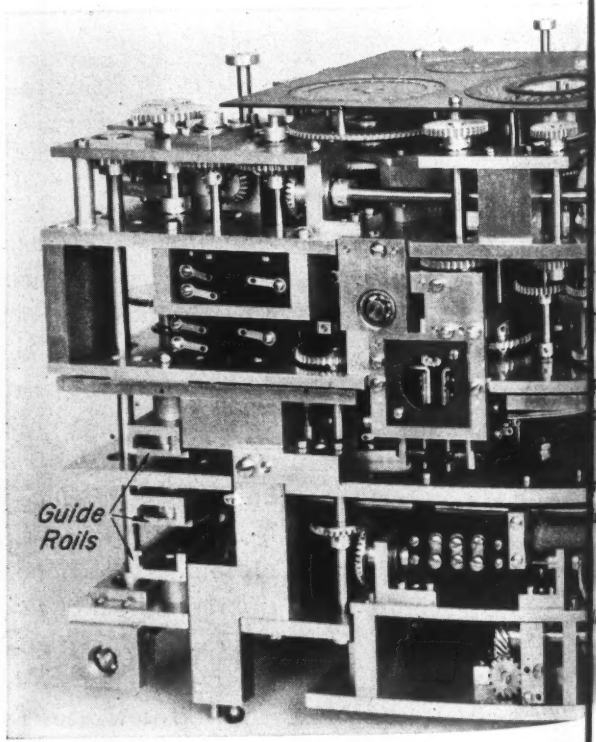
Maximum value of y	Maximum error in z, per cent of max. output
0°	0
15°	0.44
30°	1.81
45°	4.22

Values in the foregoing table are determined as follows: Absolute error in $z = \sin^{-1}(x \sin y) - xy$, where y is in radians; relative error $= e =$ absolute error/maximum z. maximum z occurs where $x = 1$, at which time $z = y$ therefore

$$e=\frac{1}{y}\left[\sin^{-1}(x \sin y)-xy\right]$$

$$=\frac{\sin^{-1}(x \sin y)}{y}-x$$

Fig. 13—Below—Partial view of a continuous computing mechanism, showing guide rails for carrying the slides of a proportional movement multiplier



The value of x that gives the maximum value of e, found by differentiating and setting equal to zero, is given by the following equation:

$$x = \sqrt{\frac{1}{\sin^2 y} - \frac{1}{y^2}}$$

Substitution of this value in the foregoing expression for e gives the maximum relative error. Percentage figures in the table are equal to $100e$.

From *Fig.* 14 it can be seen that the x input positions a traveling nut by means of a lead screw on the input sector. A pin on this nut protrudes through the slot on the output sector crosspiece. This pin, obviously, cannot be brought much beyond the pivot point of the sector, except by means of a long extension, which would be poor mechanically. Consequently this input cannot have both positive and negative values. However, if a constant is added to this input equal to the most negative value, negative quantities can be handled. In this case the output of the multiplier will be:

$$y\,(x + k) \equiv xy + ky \equiv z + ky$$

If ky is now subtracted from the output by means of a differential (see *Fig.* 10, Part I), as shown in schematic form in *Fig.* 15, the final result will be z. Attention is drawn to the convenient schematic representation of the differential used in *Fig.* 15 and subsequent diagrams.

Since the sector arms are rather long and flexible and are supported only on the ends, it is customary to shroud the pinions engaging them to prevent their falling out of mesh. A shroud is simply a flat disk, placed on either side of the pinion, and extending in the form of a flange beyond the teeth. These flanges support the sectors and prevent axial movement.

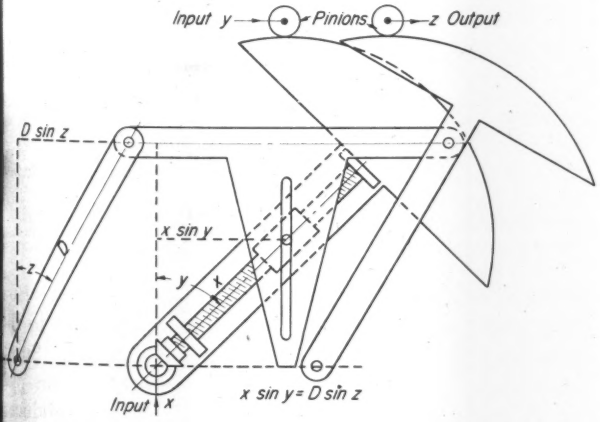
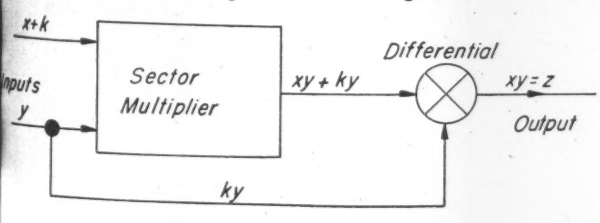


Fig. 14—Above—Sector type multiplier, which is mechanically simpler than that shown in Fig. 12 but which involves a slight error in result

Fig. 15—Below—Sector multiplier arranged for negative input. Constant k is equal to most negative value of x



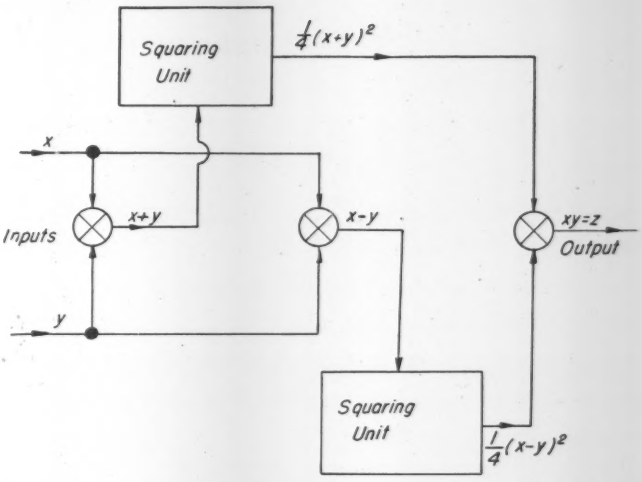


Fig. 16—Quarter squares multiplier, a recent development which promises wide use. Squaring unit shown in Fig. 17

Since the x lead screw is carried on the y input sector it must be able to swing. Consequently the connection to this screw must be by means of either a universal joint, or a pair of miter gears, the driving gear of which is coaxial with the pivot.

If miter or bevel gears are used there will be a slight additional error produced by planetary rotation of the screw as the sector arm swings. This will occur as an error in the x input of magnitude depending upon the maximum swing of the arm, the lead of the screw, and the ratio of the bevel gears. If N_1 = number of teeth in bevel gear on screw, N_2 = number of teeth in mating pinion and L = lead of screw (inches per turn), then the error Δx (per cent) is:

$$\Delta x = \left(\frac{N_2}{N_1}\right)\left(\frac{L}{D}\right)\left(\frac{y}{360}\right)(100)$$

where y is expressed in degrees. This error normally is negligible in comparison with the other errors.

Avoiding Planetary Error

When flexible shafting or a universal coupling is used to drive the x input screw, there will not be any planetary error if the shafting or coupling lies in the plane of the sector. With certain types of universal (such as the single Hooke's joint) there will be an exceedingly small periodic error as the screw turns, of magnitude depending upon the angularity of the shafting. The derivation of this error is given in most textbooks on Kinematics. The maximum value is

$$\tan^{-1}\left[\frac{\sqrt{\sec A} - \sqrt{\cos A}}{2}\right]$$

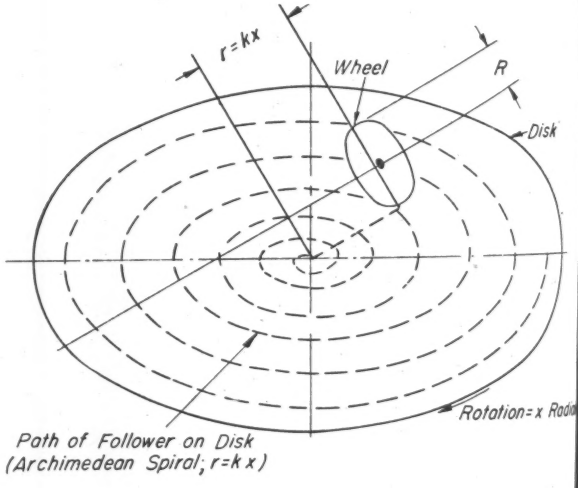
where A is the angularity of the shafts (or swing of the sector).

GEAR CAM—QUARTER SQUARES MULTIPLIER: This multiplier[3] is a recent development which promises wide use. It works on the principle of Quarter Squares, which

[3]U. S. Patent 2,194,477.

Fig. 17—Above—Gear cam type squaring unit in which output wheel rotation is proportional to square of disk rotation

Fig. 18—Below—Principle of the gear cam squaring unit showing relative movement of output wheel and input disk



states that one-fourth the square of the sum of two numbers minus one-fourth the square of their difference is equal to their product:

$$z=\tfrac{1}{4}(x+y)^2-\tfrac{1}{4}(x-y)^2$$
$$=\tfrac{1}{4}(x^2+2xy+y^2)-\tfrac{1}{4}(x^2-2xy+y^2)$$
$$=xy$$

Fig. 16 shows in schematic form the arrangement for accomplishing this. $(x + y)^2$ and $(x - y)^2$ are computed by means of squaring units, usually of the gear cam type, typical construction of which is shown in *Fig.* 17. The principle of operation is as follows.

Referring to *Fig.* 18, assume the disk to be rotated by a given quantity, designated x. In frictional contact with the disk is a wheel which is constrained to move radially in direct proportion to the rotation of the disk. The path of this wheel will thus trace an Archimedean spiral on the disk. The wheel also will rotate at a rate proportional to the rate of rotation of the disk and the instantaneous radius, r, to the wheel, as shown in *Fig.* 18. Expressing this in mathematical terms, if x = angular rotation of disk, r = instantaneous radius of contact = Kx, where K is "lead" of spiral per radian, y = angular rotation of wheel, and R = radius of wheel, then

$$Rdy=rdx$$

or

$$Rdy=Kxdx$$

Integrating:

$$y=\frac{K}{R}\int_0^x x\,dx$$
$$=\frac{Kx^2}{2R}$$

Thus it will be seen that the output wheel rotation is proportional to the square of the input disk rotation. However, thus far frictional contact, which is subject to slippage and loss of calibration, has been assumed. Substitution of a spur gear for the output wheel, and the placing of teeth along the spiral of the disk will produce positive drive. The shape of each tooth can be a figure of revolution produced by revolving the basic rack tooth of the gearing system used. In the case of involute gearing such teeth would be truncated cones. The proper spacing of the teeth may be determined as follows: Let P = diametral pitch used and T = tooth number, then

$$y=T\frac{\pi}{PR}=\tfrac{1}{2}\frac{K}{R}x^2$$

$$x^2=\frac{2\pi}{PK}T$$

$$x=\sqrt{\frac{2\pi}{PK}T}\text{ radians}$$

$$r=Kx=\sqrt{\frac{2\pi K}{P}T}$$

From these last two formulas can be computed the polar co-ordinates of each tooth. Note that the tooth at the center of the disk is tooth zero.

The output pinion is mounted on a square or splined shaft, so that it can slide axially on the shaft and at the same time rotate it. It is held in mesh with the teeth on the cam by a guide shoe or saddle which bears on adjacent teeth and causes the pinion to follow the spiral, see *Fig.* 17.

Offset Follower: In *Fig.* 18 it will be observed that the plane of the output wheel always is inclined more or less to the tangent of the spiral, approaching 90° at the center of the disk. This leads to mechanical difficulties near the center, as the output pinion may interfere with teeth at other points on the spiral. Happily, this can be overcome simply by offsetting the follower so that its axial movement is not along the radius of the disk but some distance below it. The form of the spiral then becomes the involute of a circle having a radius equal to the offset distance. Referring to *Fig.* 19, when the follower arm rotates through the differential angle, dx, the follower arm radius lengthens by the differential amount dr (actually the cam rotates and the follower arm remains stationary, but the relative motion is as described). In order for the radius arm to remain normal to the spiral, $r + dr$ must be equal to $r + A\,dx$, where A is the radius of the circle of involution, whence $dr/dx = A$. The differential length of the spiral is $r\,dx$, which is of course equal to the travel of the pitch circle of the output gear, or:

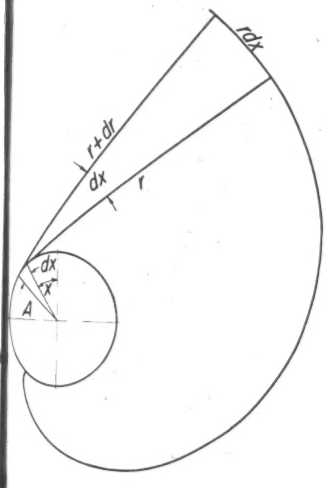


Fig. 19—Left—Shape of spiral (involute) when gear cam follower is offset. This design avoids interference of output pinion and teeth near center of disk

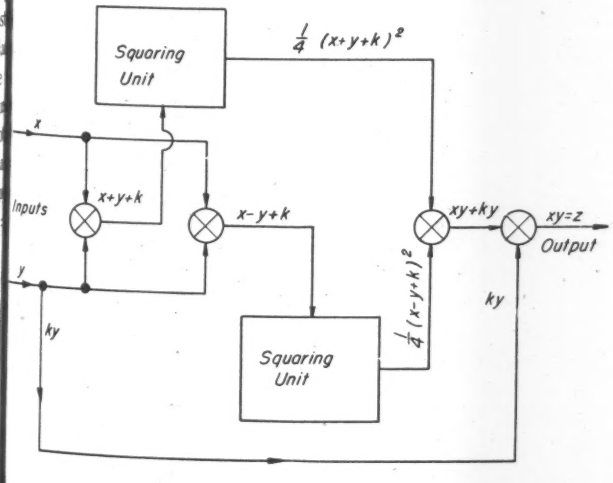


Fig. 20 — Below — Quarter squares multiplier arranged for negative input. Constant k is equal to the most negative value of either input quantity

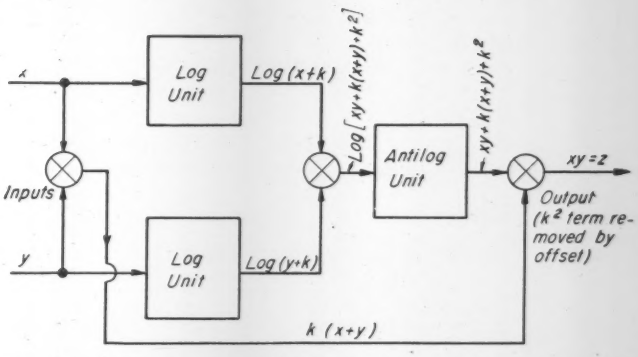


Fig. 21—Logarithmic multiplier, with provision for negative input values. Log and antilog converters may employ any type of computing cam or equivalent mechanism

$$rdx=Rdy$$

$$r=R\frac{dy}{dx}$$

Differentiating, $$\frac{dr}{dx}=R\frac{d^2y}{dx^2}=A$$

Since the function to be computed is

$$y=\tfrac{1}{2}\frac{K}{R}x^2$$

$$\frac{d^2y}{dx^2}=\frac{K}{R}$$

Therefore:

$$A=R\left(\frac{K}{R}\right)=K$$

In other words, the offset distance must be equal to the lead per radian.

Data for locating the teeth are, of course, computed in the same way as before, but r now means the distance of the tooth from the point of tangency of the offset circle, instead of from the center of the cam. It is not necessary to compute the distances from the center of the cam in laying out the teeth, because it is just as easy to measure from the offset point.

Manufacture of Gear Cams: A variety of methods have been used in manufacturing these cams. The most obvious way is to make the conical teeth separately in a screw machine, and insert them in holes drilled at the proper locations in the cam. When only a small number of cams are to be made this is a satisfactory method, but it is too time-consuming for quantity production. A good method for high production is die casting. Punch extrusion of the teeth into a die also has been used successfully, but is apt to give weaker teeth. A method used by our company has been to cut them out of the solid with a fly

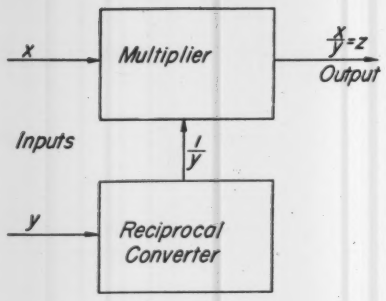


Fig. 22—Left—Setup for performing division by means of a reciprocal converter and one of the multipliers already illustrated and discussed

cutter in a special machine, which is indexed automatically by a master cam. This method is fast and accurate, and produces strong teeth integral with the disk. Another firm has generated the teeth with a Fellows-type shaper. This method produces modified rack teeth similar to those in face gears.

NEGATIVE NUMBERS: It probably has occurred to the reader that since the gear cam can handle values of but one algebraic sign, some difficulty will be encountered when dealing with quantities that can vary from positive to negative. This difficulty can easily be resolved in a manner similar to that described in connection with the sector multiplier. A constant is added to each cam input equal to the most negative value either input can assume. Let this quantity be k. Then output of combined cams is:

$$\tfrac{1}{4}(x+y+k)^2-\tfrac{1}{4}(x-y+k)^2$$

$$=\tfrac{1}{4}(x^2+y^2+k^2+2xy+2kx+2ky)$$

$$-\tfrac{1}{4}(x^2+y^2+k^2-2xy+2kx-2ky)$$

$$=xy+ky$$

The ky term is subtracted out in a differential, leaving xy. The connections are shown in schematic form in *Fig.* 20. It should be noted that this procedure is generally necessary even when x and y do not themselves actually change sign, because it is usually possible for the $(x\text{-}y)$ terms to become negative anyway.

LOGARITHMIC MULTIPLIER: In this multiplier the two input quantities are converted to logarithmic functions by suitable means and added, thereby producing the logarithm of their product. This quantity then is reconverted to the linear scale by an antilog converter. Since the logarithm of zero is minus infinity, it is evident that the inputs to the converters cannot go negative, and must, in fact, have a finite minimum positive value. Consequently constant quantities, somewhat greater than the maximum negative values, must be added to the two inputs, and their effect removed later. This process is demonstrated in the schematic diagram, *Fig.* 21. The combined output of the two log units is

$$log\ (x+k)+log\ (y+k)$$

$$\equiv log[(x+k)(y+k)]$$

$$\equiv log[xy+k(x+y)+k^2]$$

which after reconversion in the antilog unit becomes $xy + k(x + y) + k^2$. Term $k(x + y)$ is obtained from the two inputs by a differential and is subtracted from the output of the antilog unit, and the k^2 term is removed by a constant offset, leaving xy.

The log and antilog converters may be any of the various types of computing cams. The so-called "queer gear" and tape wheels also have been used for this purpose. These will be discussed in more detail in a subsequent article in this series.

DIVISION: Division of two variables

$$z=\frac{x}{y}$$

obviously could be performed simply by reversing one of the previously described types of multiplier. In some cases this can be done, but the designer must beware of danger. As the divisor approaches zero, the quotient of course approaches infinity, which means a tremendous increase in the ratio from output to input. When the multiplier was used in the conventional way for multiplying, the ratio of output to input motion approached, as a top limit, the same value the ratio now approaches as a bottom limit. Thus even a small mechanical force on the output may be greatly magnified at the input, which effectually limits the divisor to a minimum of something like 50 per cent of its maximum value. It is also evident that the maximum value of x cannot exceed 50 per cent of its possible travel, or z would exceed 100 per cent when y is 50 per cent, thereby running it against its limit and perhaps damaging parts.

A better method is to compute the reciprocal, $1/y$, and then multiply this quantity by x in a conventional multiplier, as shown in *Fig.* 22. The reciprocal can be computed by one of the various types of cam mechanism to be described in Part III.

There is another way to divide with a multiplier alone

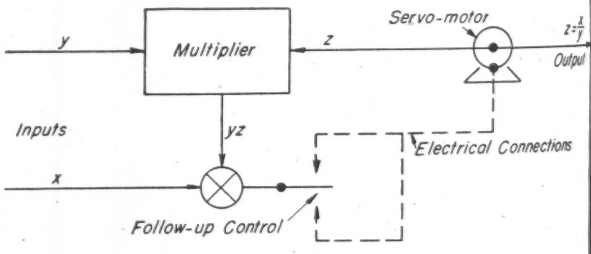
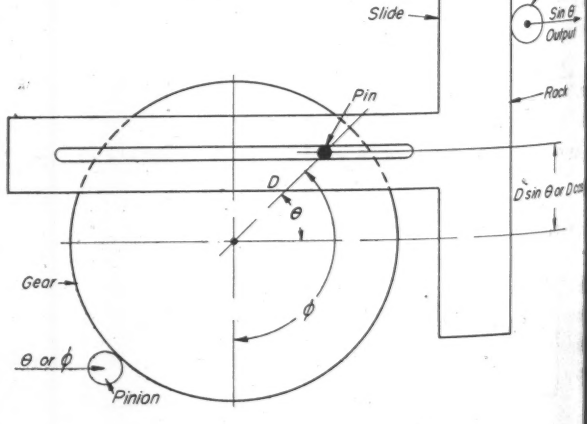


Fig. 23—Above—Arrangement for performing division using a servo-motor and a multiplier unit

Fig. 24—Below—Scotch yoke mechanism for obtaining sines or cosines. Slide is guided for vertical movement



t it requires a servo-motor. *Fig.* 23 shows the schetic arrangement for this method. A servo-motor drives e input, z, of a multiplier, the other input to which is e variable, y. The output, yz, then goes to a differenl, where the other variable, x, is subtracted from it. e difference $(yz-x)$ then operates a follow-up conl which controls the action of the servo-motor. This nses the motor to drive until the control is neutralized, which time $zy - x = 0$ or $z = x/y$.

The follow-up control consists essentially of a movable ntact, driven by the output of the differential, which sectively engages one of two fixed contacts. The direcn of rotation of the motor depends upon which conct is made. When the output of the differential is zero, e movable contact lies between the two fixed contacts, d is said to be "neutralized". The design and construcn of follow-up controls will be discussed in more detail a subsequent article, in connection with servos.

Geometric Computation of Trig Function

TRIGONOMETRIC FUNCTIONS: Two methods generally ed in computing trigonometric functions might be desnated the geometric and the tabular. The geometric thod consists of setting up the trigonometric vectors echanically and then "taking off" the various functions movements of appropriately placed slides. With the bular method the various functions are computed by ms or cam-type mechanisms. Which method to use is nerally determined by the accuracy requirements and e mechanical feasibility. The accuracy is, of course, deendent largely upon the scale used, so that for high acracy with geometric solutions the equipment tends to come extremely bulky. Also, with functions other than e sine and cosine, mechanical considerations generally strict the computation to rather narrow ranges since nly the sine and cosine have finite limits. The present ction will deal only with the geometric method. Since e tabular method does not differ from any other compuation involving cams, it is covered in a later section on at subject.

SINE AND COSINE: These functions are computed by e familiar Scotch yoke mechanism (*Fig.* 24). If the dius to the pin is taken as the unit of measurement, en the vertical motion of the slide represents the sine or sine of the angle, depending upon the axis of reference. ften two slides are used, moving along axes at right ngles. The pin extends through slots in both slides, thus roviding both sine and cosine simultaneously. The rails arrying the slides are constructed like those in the proortional movement multiplier.

COMPONENT SOLVER: This is a common form of sine-osine mechanism, and is shown in *Fig.* 25. It includes n additional input to permit changing the vector length, as well as angular position, θ, and solves the equations:

$$x = r \cos \theta$$

$$y = r \sin \theta$$

s shown, the pin is carried on a crosshead in the angle lear, the crosshead being moved radially by a rack and inion at the center. Other methods might be used; for xample the pin might be carried on a traveling nut driven

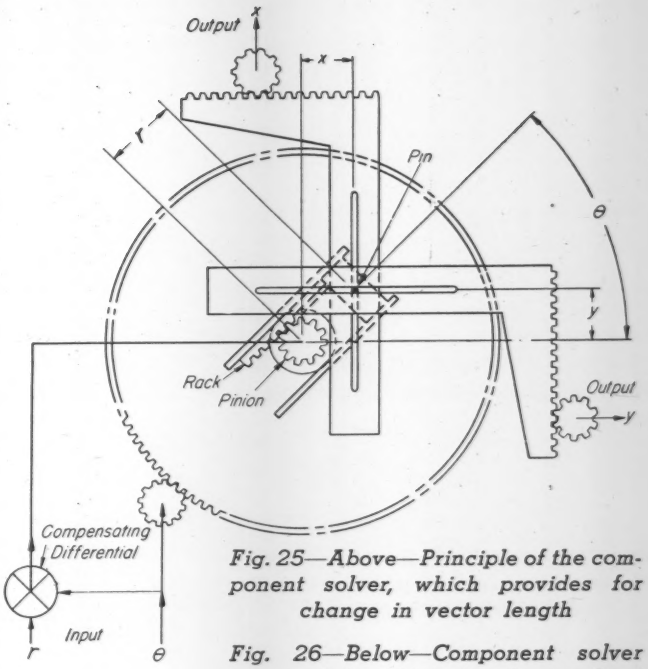
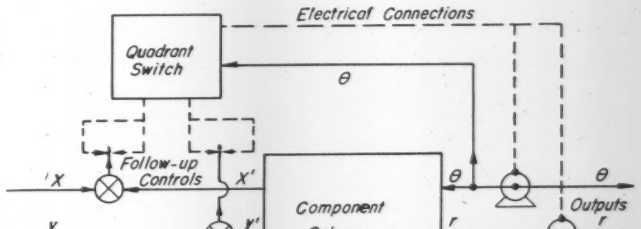


Fig. 25—Above—Principle of the component solver, which provides for change in vector length

Fig. 26—Below—Component solver arranged for obtaining the resultant of two components



by a lead screw, the latter being turned by a pair of miter gears located at the center.

Note the compensating differential in *Fig.* 25. If this were not present, rotation of the angle gear would cause a change in the length of the vector. With this differential, a change in angle rotates the angle gear and the vector pinion equally, so that there is no relative motion of the pinion and rack. A change in the length input, however, changes only the vector length.

When Resultant of Components Is Needed

COMPUTATION OF RESULTANT: Occasionally a problem will arise which requires that two components, x and y, be combined to form the resultant vector r, θ. This can be accomplished with a component solver by the use of servo-motors and a quadrant switch. *Fig.* 26 shows the schematic arrangement. The angle and vector length inputs to the component solver both are driven by servo-motors. The computed components, designated x' and y', are "matched" with the corresponding incoming x and y components by differentials. The outputs of these differentials drive two follow-up controls which in turn control the two servos through the quadrant switch. When the vector represents the correct resultant, $x' = x$ and $y' = y$, the control contacts are neutral and the servos are at rest. The quadrant switch, driven by the angle, determines

which follow-up control is connected to which servo, and also the sense in which it is connected. The reason for this will be made clear by the following:

Between 45° and 135° the angle, θ, is principally affected by the x component ($x = r \cos \theta$), and in a sense such that an increase in x causes a decrease in the angle. On the other hand the vector length, r, is principally affected by the y component ($y = r \sin \theta$), and in a sense such that an increase in y causes an increase in the length. Consequently, for the region between 45° and 135° the quadrant switch connects the x follow-up control to the angle servo and the y control to the length servo, and in the manner to produce the senses indicated in the foregoing. The mutations for the other quadrants, 135° to 225°, 225° to 315° and 315° to 45°, can readily be traced by the reader.

It may now be asked, "Although the x component will principally affect the angle in the region 45° to 135°, it should also have some effect on the length. With the connections as in the foregoing how is this brought about?" The answer is, through the other control. If a small change occurs in, say, the x component only, the angle servo begins to drive to accommodate the change. [illegible] tion of the angle gear tends to change y' also, which [illegible] tuates the y control (since y has not changed) and caus[illegible] the length servo to drive so as to maintain $y' = y$. Th[illegible] a change in x produces changes in angle and length [illegible] most simultaneously, and they would so appear to anyo[illegible] watching the operation. Actually all the quadrant swit[illegible] does is to decide which servo *initiates* the computatio[illegible] It will now be evident that the transfer points are not cr[illegible] ical, so the switch is made with an overlap of about 10[illegible] For example the transfer takes place at 50° when th[illegible] angle is increasing, and at 40° when decreasing. This[illegible] to avoid any hiatus which would occur if the vector ha[illegible] pened to be wandering about in the vicinity of a sharp[illegible] fixed transfer point. The switch is, of course, snap actio[illegible] so that the connections are always either one way or th[illegible] other; otherwise the servos might get "hung up" on th[illegible] transfer point.

When the vector length becomes zero, the angle com[illegible] putation naturally becomes indeterminate, since a poi[illegible] can have no angular position. Therefore as the vect[illegible] approaches zero length, small influences such as backla[illegible] tend to have a great effect on the accuracy of the ang[illegible] determination and the angle servo may wander, taking u[illegible] the backlash first one way and then the other. Cons[illegible] quently it is a good plan to have a limit switch which w[illegible] cut out the angle servo whenever the length setting go[illegible] below a minimum value, as determined by test of th[illegible] particular design.

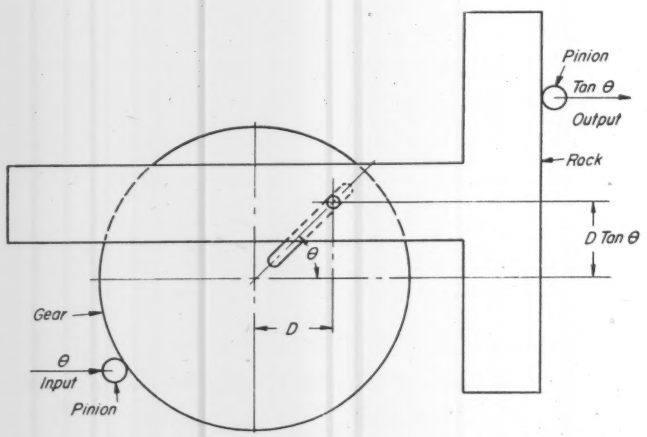
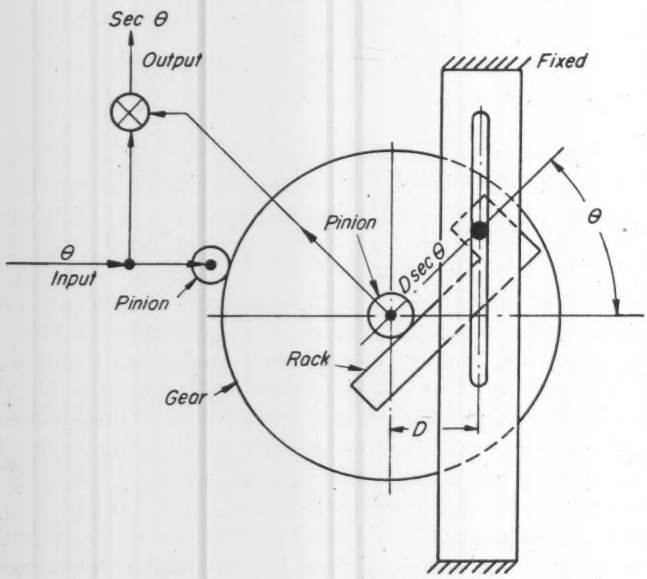


Fig. 27—Above—Tangent computer, also used for obtaining cotangents by rotating axis of reference 90 degrees

Fig. 28—Below—Secant computer of the geometric type, which is suitable for angles up to 30 degrees



Range of Tangent and Secant Mechanism Limited

TANGENT AND COTANGENT: The mechanism for co[illegible] puting the tangent is shown in *Fig.* 27. It differs fr[illegible] the sine mechanism in that the pin is on the slide and t[illegible] slot on the rotating arm. Mechanical considerations usu[illegible] ly limit this computer to about ±45°. The cotang[illegible] mechanism is identical except that the axis of referenc[illegible] rotated 90°.

SECANT AND COSECANT: *Fig.* 28 shows an arrangem[illegible] for computing the secant. In this case the pin is carr[illegible] on a rack sliding in the arm and engaging a pinion at [illegible] center, and works in a slotted guide at a fixed unit [illegible] tance, D. Note the compensating differential. [illegible] cosecant mechanism is identical except for a 90° rotat[illegible] of the reference axis. Since geometric methods are [illegible] suitable for secants of angles much larger than about [illegible] cams or cam-type mechanisms almost invariably are u[illegible] instead, and this practice is recommended to the rea[illegible]

In all the foregoing mechanisms, motion is transfe[illegible] from input member to output member by means of a [illegible] running in a slot. It is of the utmost importance that [illegible] pin slide freely, yet maintain a close fit with the slot. [illegible] this reason the pins should be equipped with rollers. S[illegible] ball bearings are satisfactory for this purpose, the ou[illegible] races being in contact with the sides of the slot, and [illegible] inner races forced over the pins.

Third article in this series, to be published next mo[illegible] will be concerned with cams and other tabular mech[illegible] isms for solving mathematical relations which resist co[illegible] putation by methods such as those already discussed.

Special-Purpose Motors Meet Unique Requirements

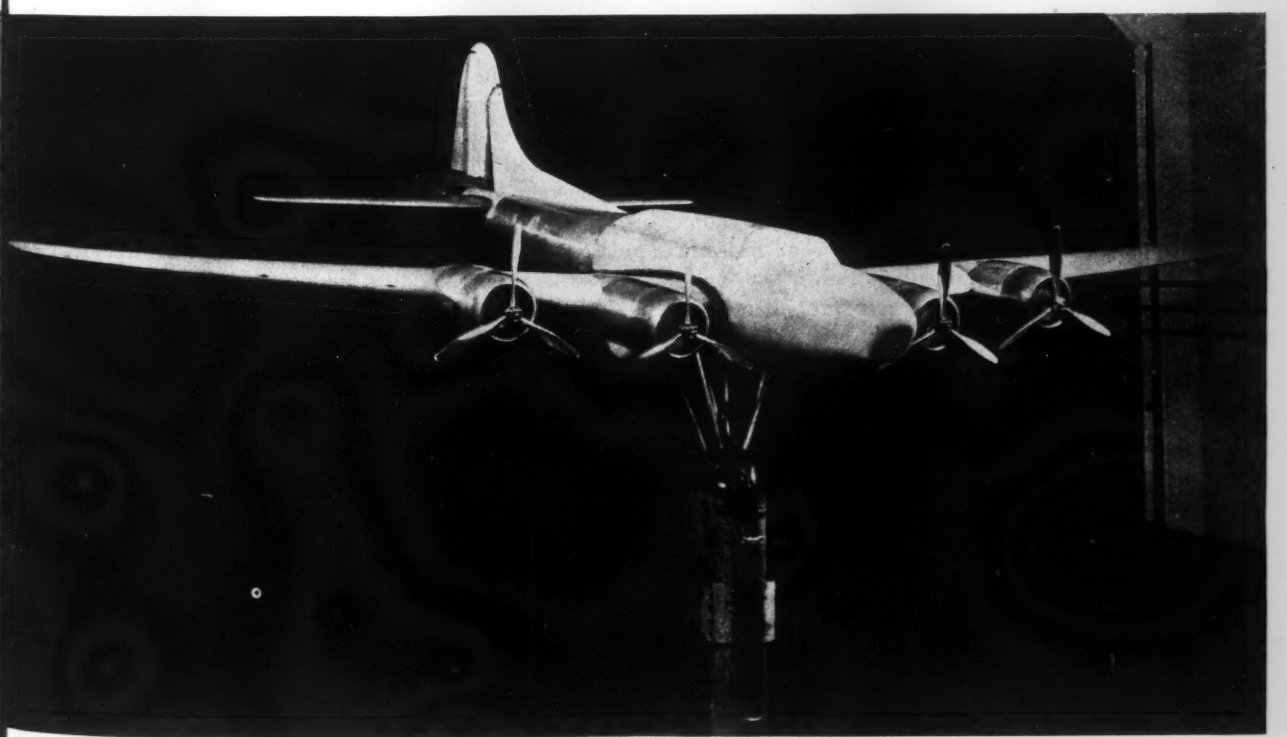
By Marion B. Sawyer

ABNORMAL speed and power requirements, often a necessity in special machines, frequently present extraordinary design difficulties. Where these cannot satisfactorily be solved through the utilization of standard equipment, electric motors specifically developed for the job from the ground up may be necessary.

Successful design with special-purpose motors involves careful consideration of machine requirements or "to-be-

Fig. 1—"Power-On" motor with a propeller mounted ready to be installed in a wind-tunnel model

Fig. 2—Below—Four-motored airplane model mounted in wind-tunnel ready to be tested. Each propellor is driven by a high-frequency motor similar to that shown in Fig. 1



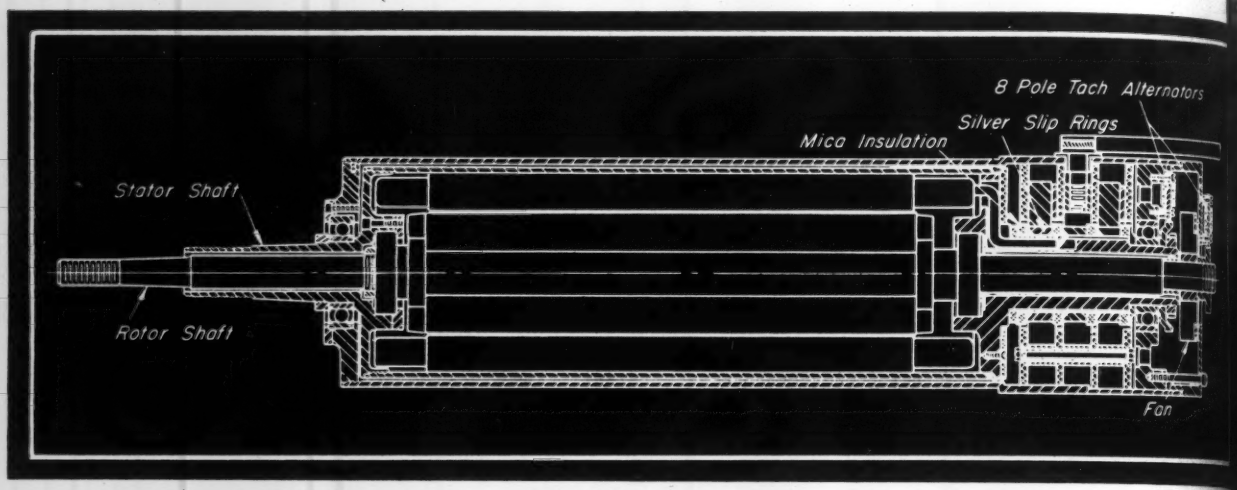
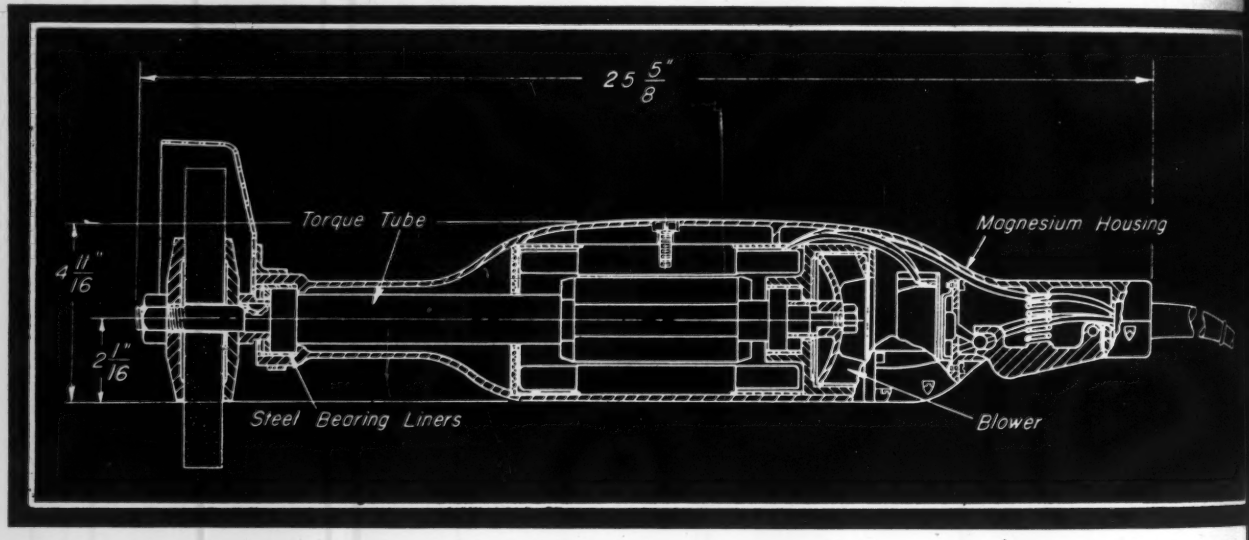


Fig. 3—Above—Counter-rotation co-axial motor designed to drive counter-rotating propellers in wind-tunnel work

Fig. 4—Below—Extremely lightweight hand grinder. Special motor makes possible a 2-hp, 16-pound tool

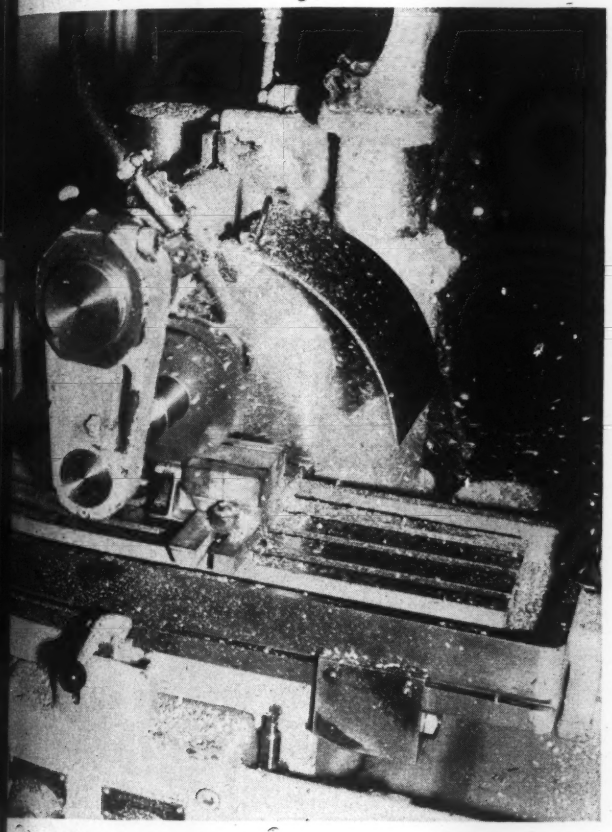


met" specifications. Of these, maximum horsepower-to-weight ratio, restricted diameter, abnormal speeds, and waterproof or explosionproof construction are but a few. A special machine application might stress high-speed and small housing diameter, with overall length and weight of no importance. In a submersible pump or mine motor, dimensions might be overlooked in favor of resistance to water or mine gases. In a so-called "Power-On" motor for driving wind-tunnel model aircraft propellers (*Fig.* 1), space factor, diameter, and length usually are so combined as to provide maximum intermittent horsepower output with the weight factor overlooked. Obviously then, the "Power-On" or wind-tunnel motor would not meet the requirements of a hand tool such as a portable grinder, where least weight per horsepower becomes the primary design consideration.

The engineering of such special electric motors is unique to the extent that it seems as though no definite rules can be applied to the many phases of the subject. In occasional cases novel or unorthodox methods have been evolved to enable the fulfillment of particularly difficult specifications. For example, there is the use of a coolant gas admitted through a hollow rotor shaft and expended against the stator end coils and shell to control mot temperature. Again, there are heat transfers, special impre nation for moisture proofing, etc. The motor shown in *Fi* 1 is nothing more than the portrayal of an internal com bustion airplane engine reduced in exact scale to fit i a model plane, (*Fig.* 2), to be used for wind-tunnel testi Here four of these motors furnish power for driving pr pellers remotely to produce in the model the same aer dynamic effect as its gasoline engine counterpart in t full scale plane. In this type of special motor design m manufacture, cost of construction is no object and co sideration of the cost of maintenance is of little importan as long as there is sufficient life to carry through t required test. For this reason fine silver frequently is use for rotor bars, impregnating compounds costing as muc as ten dollars per gallon for special coils, high quali stainless steels for motor shafts, and expensive metals fo heat transfer purposes.

Nearly every wind-tunnel plane model requires a mot or motors with entirely different space factor and powe output. A great many of the motors used for applicatio such as that shown in *Fig.* 2 are designed to the limit produce the greatest possible horsepower in the small

ssible space. Some conception as to comparative size and wer can be gained from the general characteristics of me water-jacketed motors which follow: One model inches in outside diameter by 5⅜ inches in length velops 6 horsepower at 28,000 revolutions per minute; other 3½ inches in outside diameter by 7 inches in gth develops 15 horsepower at 17,000 revolutions per nute; still a third 2¼ inches in outside diameter by 6¾ inches in length develops 3 horsepower at 18,000 revolutions per minute. In these units, pure silver rotor bars and end rings were used as conductors, not just for the increased conductivity, but to: (1) eliminate high resistance between the bars and the end rings (silver makes a more positive bond), (2) decrease the time dwell at the high welding temperature required to unite each bar to the end ring, thereby eliminating all chance of irregular conductivity, and (3) materially decrease the chances for high welding temperature to impair the electrical characteristics of the steel laminations.



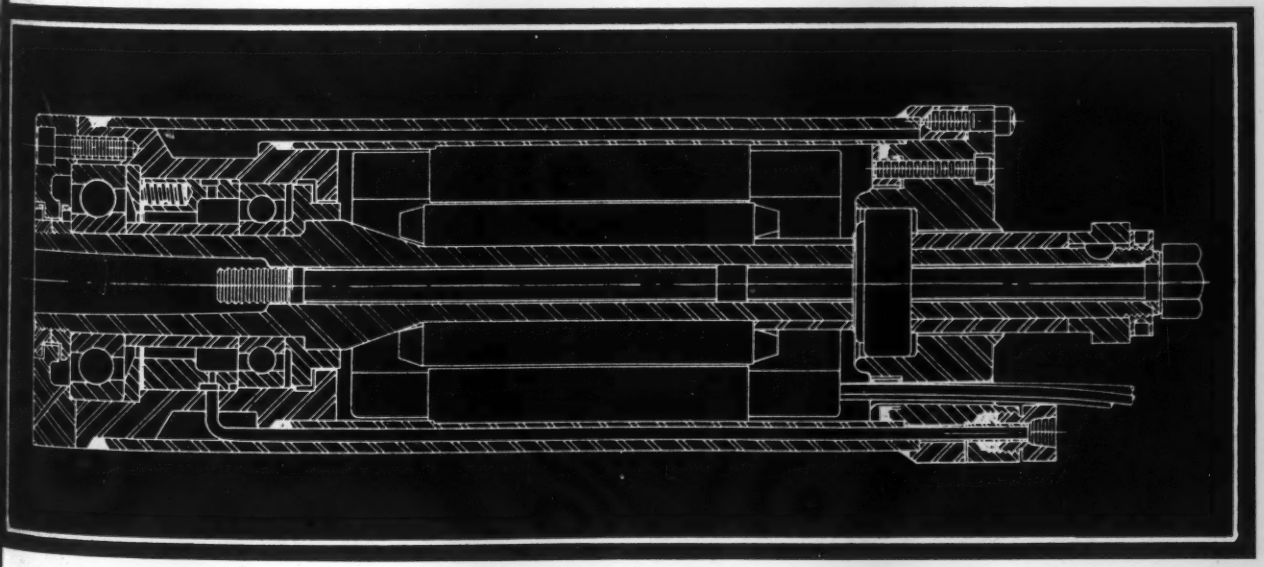
ig. 5—Above—High-frequency water-jacketed milling otor mounted in conventional milling machine. Speeds om 9000 to 15,000 rpm are instantly available with this unusually compact arrangement

ig. 6—Below—Milling motor which develops 7½ hp a 10,800 rpm on 220-volt, 3-phase, 180-cycle current

Conventional Design Failed

The co-axial counter-rotation motor shown in *Fig.* 3 is an unusual motor design which involved both space factor and weight problems. Developed to drive counter-rotating propellers in wind-tunnel work, the stator of this motor is connected to a shaft and actually revolves in counterclockwise direction while the rotor turns at equal speed in clockwise direction. The motor, wound four-pole, develops 30 horsepower on each shaft at 4000 revolutions per minute or a total of 60 horsepower output. In operation of the original model, conventional stator end coils shorted out because of the high peripheral speed of the unit. Ordinary end coil banding proved a failure because the coils, shifting slightly, threw the entire unit out of balance. This in turn caused poor commutation at the slip rings and the accompanying arcing burned the commutator bronze to such an extent the motor would not put out its full 60 horsepower at the required 4000 revolutions per minute. To cope with this problem a cupped stainless steel jacket, insulated on the inside with mica, was forced over the end coils in place of the conventional type of banding. This was then impregnated with a hard insulating varnish so that the end coils and stainless cups or holders became virtually a solid unit. Thus, coil movement was eliminated, and the stator could be balanced properly to avoid all vibration.

Material in the slip rings, after exhaustive testing, was changed to fine silver which improved commutation to an extent making possible the desired current flow in



operation. Even though the soft, ductile silver employed has a short mechanical life, it holds up sufficiently well for the intermittent demands of wind-tunnel testing. Oxide formed on the silver during operation is equally as high in conductivity as the parent metal itself, thus all detrimental sparking at the brushes is obviated.

The motors discussed in the foregoing, though definitely classed as special-purpose motors, are of such design and materials as to preclude their use for practically any of the usual commercial applications. On the other hand there are a great many new installations which will allow a high original motor cost. These fall into a class where the motor and its purpose become a single production unit such as a portable grinder, a special machine, a portable submersible pump, etc. As the name implies, portability in a machine always indicates light weight and small dimension in comparison to power output. It also means a more expensive type of motor, the user being more than willing to pay a reasonable increased cost per horsepower for the ease of transportation and handling.

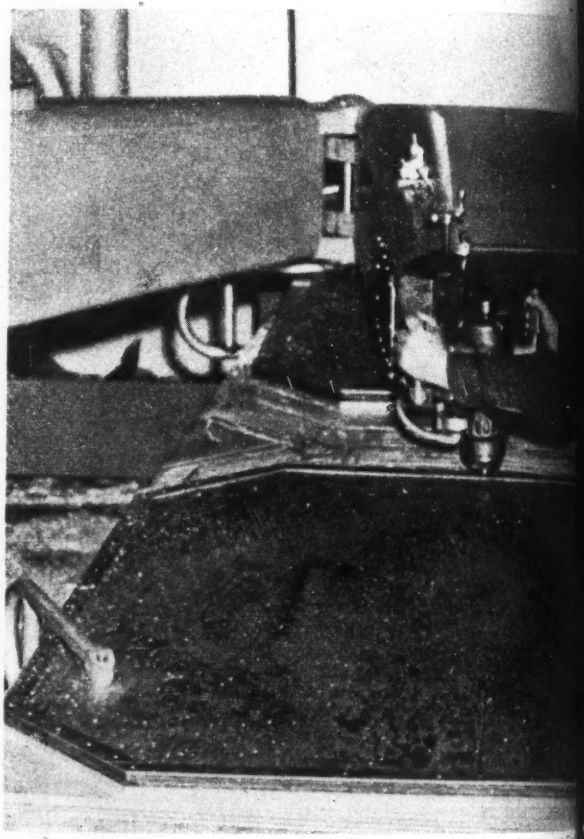
Designed to Suit Conditions

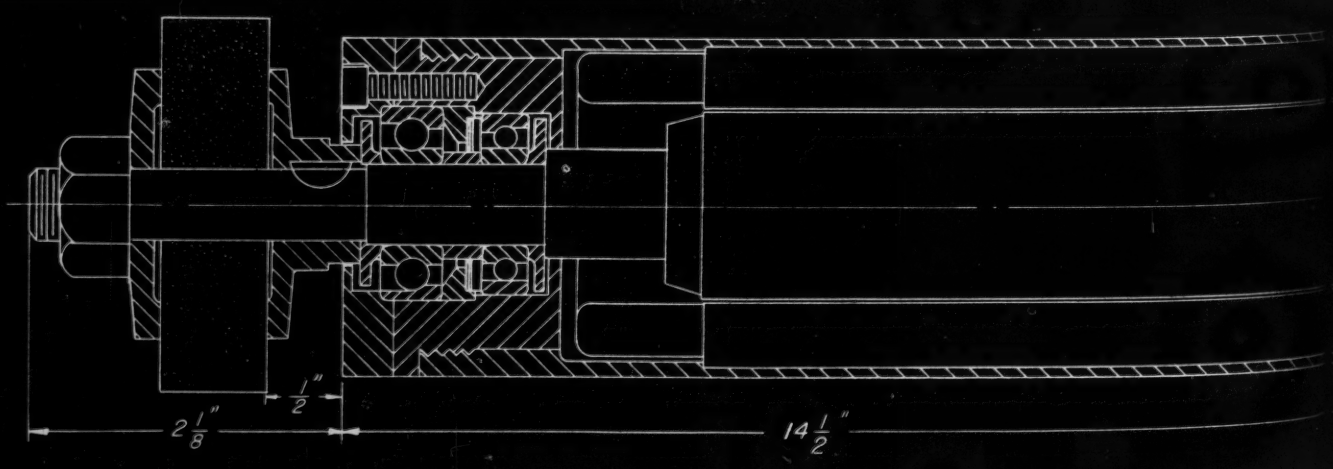
A portable submersible pump built for control of battle damage on board warships is powered by a special motor having a stator that is 4½ inches in diameter by 10⅝ inches long and a rotor that is 2¾ inches in diameter. This unit produces 7½ horsepower submerged, pumping some 200 or more gallons per minute at a 50-foot head. The water pumped is routed to flow through the unit, circulating around the stator to maintain a constant temperature.

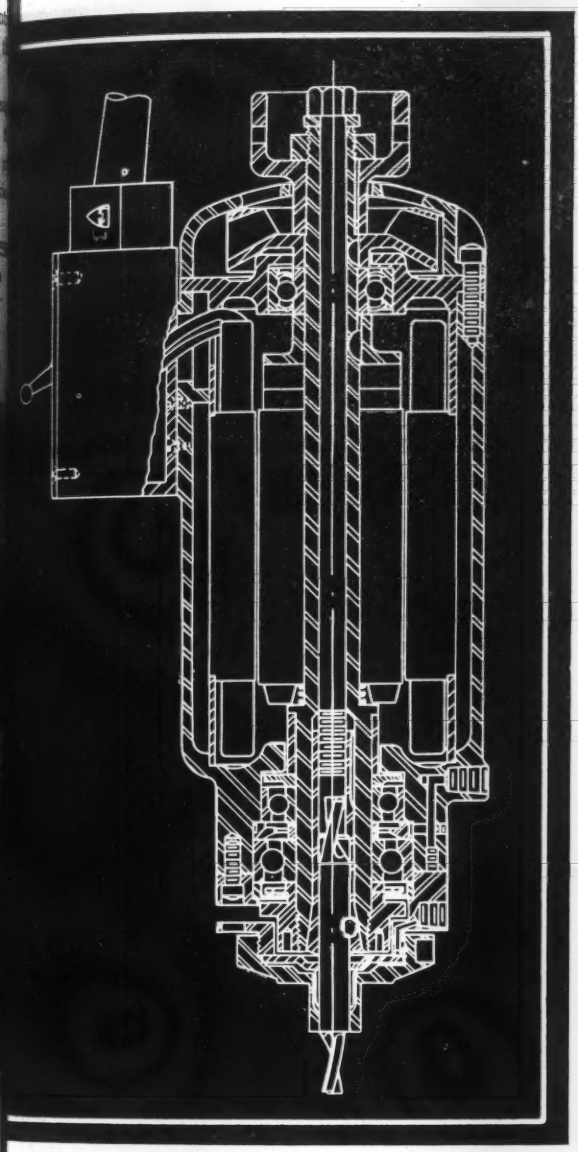
Torque driven portable grinders, (*Fig.* 4), represent a design problem opposite to that of the pump. In the pump motor, water is the ready coolant and the horsepower load is constant, while in a grinder, air is the available coolant and the horsepower duty is intermittent. This reverses both the mechanical and electrical design so that the two units scarcely resemble each other. In the pump mo efficiency and power factor are very important, but is not so in the grinder.

These portable hand grinders are illustrative of de importance rather than inventive importance, viz., number and shape of the rotor slots, width of stator and allowable rotor bore, method of impregnation,

Fig. 7—A 5-hp routing machine in operation. Using 2 cycle current this motor operates at 15,000 rpm







of material used, and heat transfer. All contribute to delicate balance of design which makes it possible to create a special lightweight grinder, similar to that shown in *Fig.* 4, which produces a constant 2 horsepower output at 3600 revolutions per minute with a pull-out of momentary load of nearly 4 horsepower. Total weight, less guard and wheel, when manufactured of aluminum is 22 pounds, and made of magnesium it is 19 pounds.

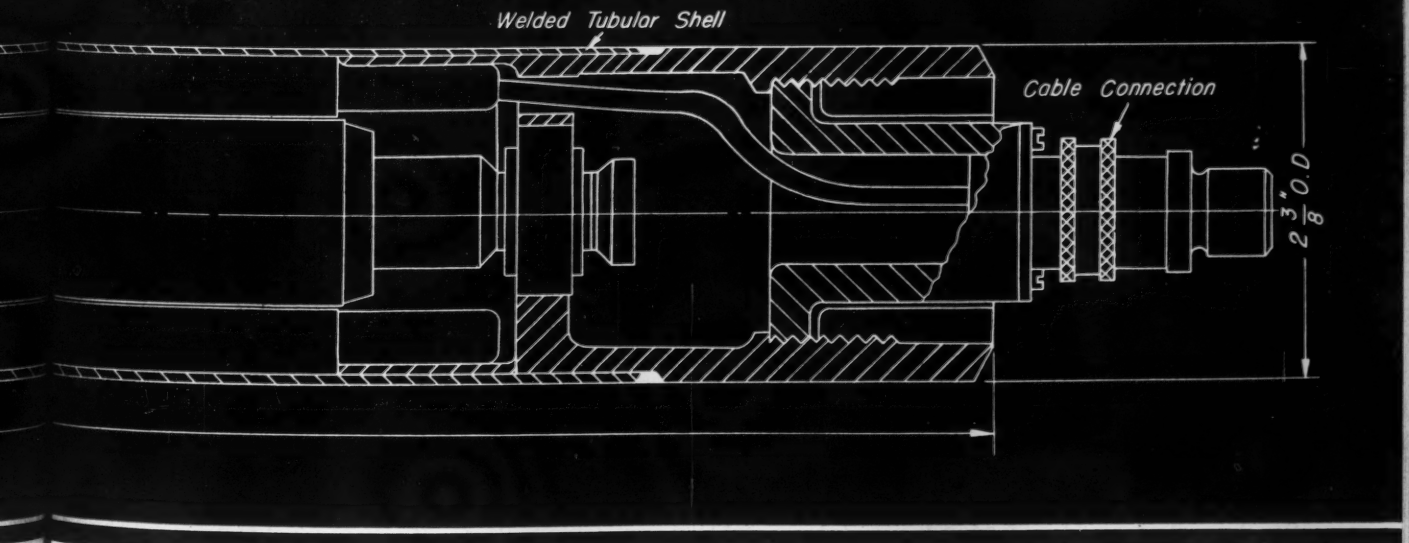
Should the same power be required in another application where possibly the stator lamination would have to be 3⅜ inches in diameter rather than 4⅜ inches as in the motor in *Fig.* 4, the total weight would be increased approximately 25 per cent. Design would change so radically that the only common factor would be that each is a polyphase induction motor. Thus, each application carries its own design problems, especially where extreme speeds obtained by high and varying frequencies are concerned. Where increased production is possible by no other means, as with machine tools and allied equipment, the motor cost assumes little importance in the over-all machine cost.

Increased Production Possible

A spectacular demonstration of high speeds (by means of high frequency) is illustrated in *Fig.* 5. This shows a milling operation on an aluminum part at one of the major aircraft companies. Cutting speeds around 2500 linear feet per minute which were first used on aluminum or dural have increased as production demands increased, until today speeds as high as 10,000 linear feet per minute are common. It has been found that such materials can be worked at higher speeds than wood when cutters with proper clearance and adequate lubrication are used. The

Fig. 8—Left—General construction details of a high-frequency motor developed especially for routing work

Fig. 9—Special-purpose grinding motor for fine internal work develops 1½ hp at 15,000 rpm on 250-cycle current. Extreme proportions indicate wide range of possibilities



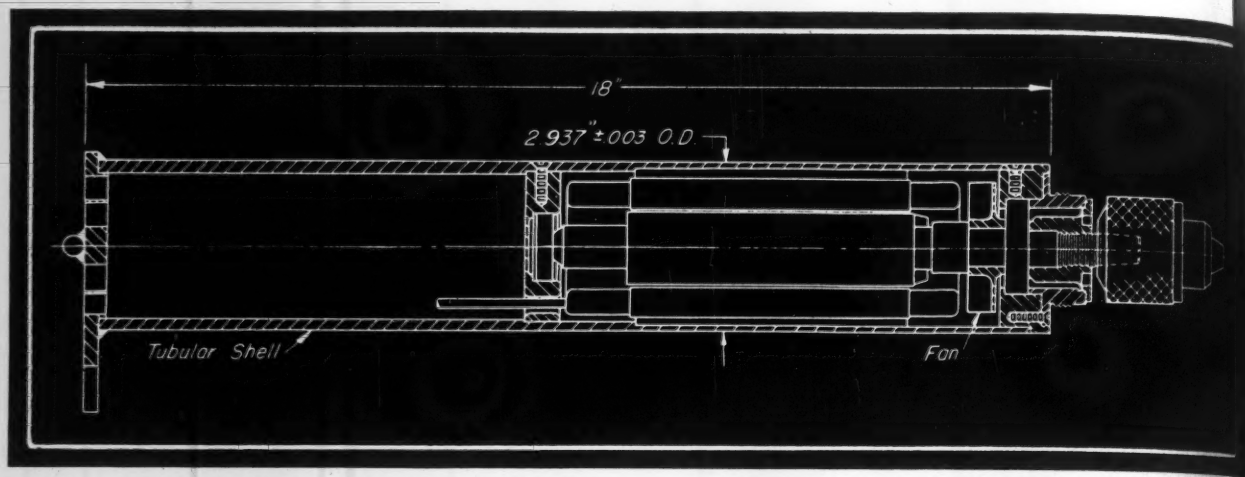


Fig. 10—A special high-speed built-in power drill spindle which develops 2 hp at 15,000 rpm

milling machine in *Fig.* 5 has a water-jacketed motor capable of developing 15 horsepower at 250 cycles, operating at a cutting speed of approximately 7000 linear feet per minute. By varying the frequency, speeds from 9000 to 15,000 revolutions per minute are available. *Fig.* 6 shows a cross-sectional view of a milling motor designed to develop 7½ horsepower on 180 cycle current at 10,800 revolutions per minute.

High-speed routing operations have improved along somewhat similar lines, *Fig.* 7. Developing 5 horsepower in operation on 250 cycle current, the router motor drives a cutter at 15,000 revolutions per minute. The sectional drawing in *Fig.* 8 shows the general construction. This router motor utilizes a fan to drive air at high velocity over the exterior of the stator for cooling. The rotor-stator air gap and interior is protected from dust and chips through the use of special sleeves which completely enclose the rotating parts. The extra cooling effect of the fan is required in this unit because the motor often is overloaded for short periods of time.

Many special type grinding machines are designed with speeds far below those desirable for maximum quality and production. To obtain in such machines, maximum efficiency, tailored-to-suit speed ranges and proper space factor, the special purpose motor often is justified. Illustrative of such a motor for fine internal grinding is the one shown in *Fig.* 9. Shell outside diameter of 2⅜ inches and the length, approximately 15 inches, represent an extreme case where length is overlooked in favor of small diameter, power and speed. Another, a 400-cycle unit develops about 6 horsepower at 24,000 revolutions per minute and is only 1⅛ inches in diameter by about 6 inches in length.

In the high-speed drilling spindle shown in *Fig.* no coolant is required other than the metal contact against the motor shell when the unit is mounted for operation. Indirect radiation or transfer of heat is sufficient in these units. The motorized drill spindle in *Fig.* exemplifies a condition where diameter is restricted but overall length is of no importance. A 2 15/16-inch diameter shell houses the motor which develops 2 horsepower at 15,000 revolutions per minute on 250-cycle current.

The foregoing may help to give the designer some idea as to the vast little-tapped possibilities of special motor applications. Suffice it to say that in any design application where quality predominates or where production increase of possibly several hundred per cent may be in order, the high cost of a special purpose motor becomes of secondary importance and in some cases of no concern at all.

B-32 Details Unveiled

Newest of the Army Air Force's big bombers, the long restricted Consolidated B-32, sister ship of the Boeing B-29, has seen action with general George C. Kenney's Far Eastern Air Forces. Featuring heavy fire power and bomb load the B-32 was designed especially for operations in the Pacific. Although certain details are not yet available, it is known to carry sizeable bomb loads for long distances at speeds exceeding 300 mph.

It is an all-metal, high-wing, single-tail monoplane with a cylindrical, semi-monocoque fuselage and a modified Davis low-drag wing with fowler type flaps. The tricycle landing gear which uses dual tires, is fully retractable and has a completely swiveling nose wheel.

Power is supplied by four double-row, 18-cylinder Wright cyclone engines of 2200 hp, each equipped with two exhaust-driven turbo-superchargers. The Curtiss four-blade electric propellers have a diameter of 16 feet inches, and are equipped with Curtiss automatic synchronizers. Propellers on the two inboard engines have reversible-pitch blades for braking during the landing run. Wing span of the B-32 is 135 feet, length is 83 feet 1 inch and height is 32 feet 2 inches. It has a wing area of 14 square feet and a gross weight of approximately 100,0 pounds. Overloaded it weighs 120,000 pounds and empty more than 60,000 pounds.

Normal crew is eight and the first of the B-32 crews to see combat were former Liberator men, except for the aerial engineers, who had finished their operational training in the Fourth Air Force. It was the first time in World War II that a new tactical type aircraft was assigned to Training Command before it was engaged in operational training in the Continental United States.

Fig. 1—Short wave diathermy machine utilizes clock escapement for timing operation

Selecting Timers for Automatic Control

Part I

By John W. Greve
Associate Editor

WHENEVER an operation or series of operations must be repeated in a definite time le, an automatic time control be utilized to initiate and con- these functions in their proper er and for the required length of time. hether timers govern plastic molding ma- nes, batch mixers, radios, domestic appli- ces or other equipment they should be se- ted with care commensurate with the ac- racy, service and dependability required. ers are used to control duration of operation, time ay after initiating impulse, opening circuit after selected iod of inoperation, and other machine functions where time interval is the controlling factor rather than se- ence operations. Increased automatic operation and nements in processing during the past years have led to development of dependable timing devices which are ilable as standard parts with a large selection of timing tures for a variety of applications.

War demands for timers have taxed manufacturing capa- to the limit and has brought about many improve- nts in design. Applications include radar, gun control, naling and manufacturing equipment. Emphasis on e of operation and accurate control indicate that post- r developments will utilize time-cycle control to a much ater extent than previously was considered practical.

Timers may be grouped according to their principle of operation. Generally this grouping gives an indication of the length of timing cycles available and the accuracy of cycling attainable. This article will discuss the features of this group except motor-driven and discuss typical timer units and their applications. Motor-driven program timers will be treated in Part II to be published in a later issue.

These groups of timers are

1. Hair-spring clock
2. Dashpot
3. Thermal
4. Condenser capacity
5. Inductive
6. Motor driven

Hair-spring clock escapement timers are designed primarily for economical and safe operation of electric or nonelectric equipment which requires time control or

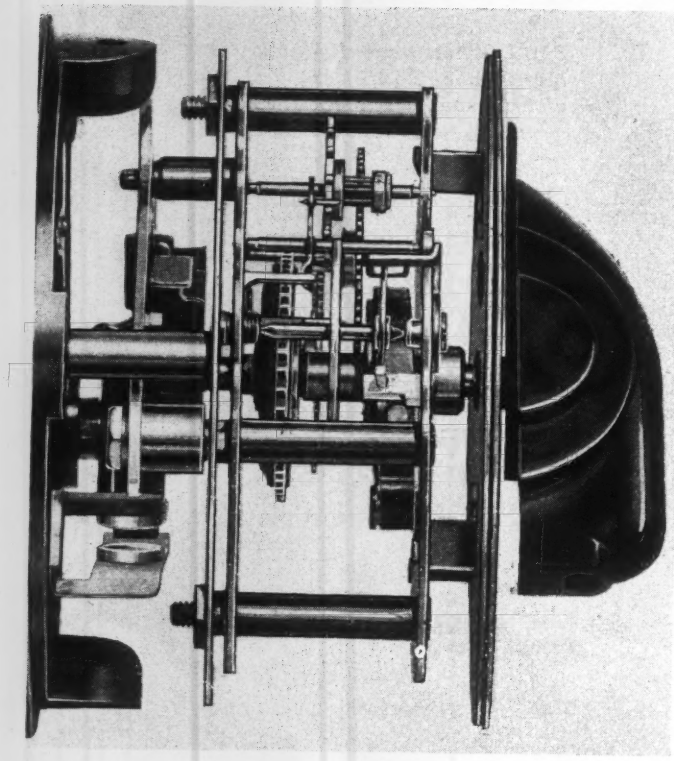
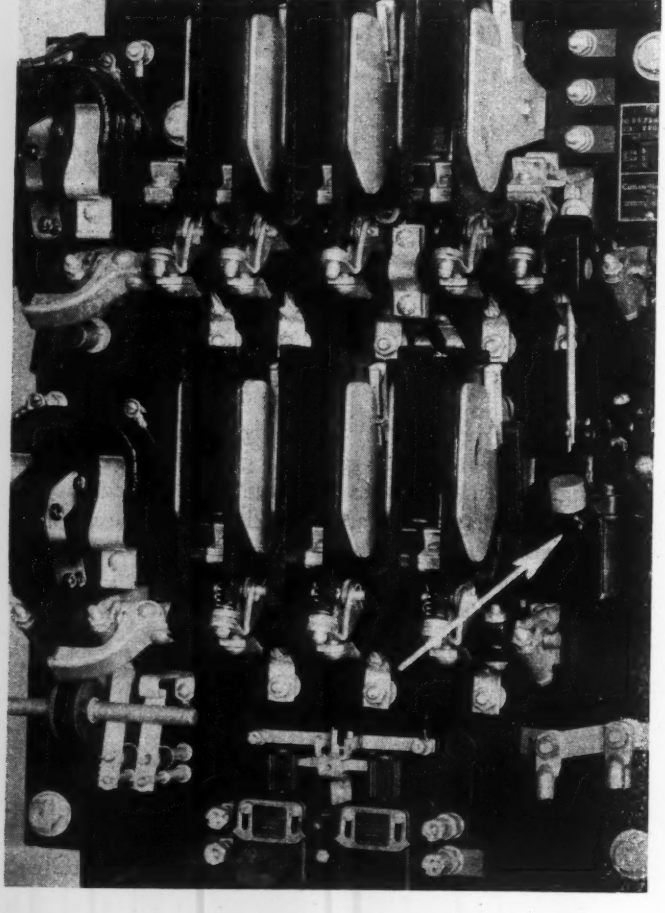


Fig. 2—Above—Clock mechanism for dial setting of time intervals up to 3 hours

Fig. 3—Below—Closing of contactor is delayed by mercury dashpot shown at right in automatic motor starter



signaling. They are usually either knob and dial lever set, the setting energizing the timer's main for the period of operation. Dial setting units are where each cycle requires variation in timing such the short-wave diathermy machine in *Fig.* 1 as well mixers, hair dryers and washing machines, and sho located in a convenient place with other major ope controls. A lever timer may be placed at an advanta location so that its lever may be set by the movement machine element or by a solenoid circuit to initiat timing cycle. If a lever timer requires frequent changes, however, consideration should be given a providing convenience in adjustment. Such adjust usually are lever or cam controlled with suitable brations. Lever timers do not have as long cycling pe as do the dial types. Their cycles are restricted to pe up to six minutes. Also contacts are usually 3 to 6 pers.

Dial timers like the one shown in *Fig.* 2 are availab 15, 30, 60 and 120-minute ranges. Electrical con are rated at 6, 15 and 20 amperes, 110-volt alterna current. They may be single or double pole, singl double throw and normally open or normally closed. clock escapement is self starting on energizing and sufficient power for snap-action switching. Some des have self-powered switch mechanisms which are when the cycle is initiated. These permit the use of sm clock movements, requiring only enough power to op the escapement. Also, the timers do not slow down to the end of the cycle because of the added trip load.

Dashpots Are Used Where Timing Is Not Precise

Dashpots are employed as timing units in relays, draulic circuits and mechanisms where accuracy is a factor and the temperature does not vary over extre Usually they are utilized to delay operation of a mecha or the closing of a circuit for a preselected interval escaping through a small hole or adjustable orifice. oil or mercury in the dashpot allows a piston to move controlled rate. Typical applications are for delay momentary power failure to preclude contactors f opening prematurely and for controlling the acceleratio motors on starting.

Conventional air and oil dashpots for relay opera are adjustable for periods ranging from 1½ to 15 seco while mercury dashpots on automatic motor starters as shown in *Fig.* 3 range between ½ and 25 seconds justment. A pneumatic timing device, diaphragm actu instead of piston, having a range of settings up to 3 min with not more variation in operation than ± 10 per c from the mean timing period is shown in *Fig.* 4. At the of the timing period the diaphragm is pushed upward action of a solenoid on the operating block. Air in the ch ber above the diaphragm is transferred to the upper ch ber through a by-pass valve. A felt filter keeps the press in this chamber at atmosphere at all times. Timing op tion is initiated when the force acting on the block removed by operation of a solenoid. This allows the co pressed operating spring to pull the diaphragm dow ward at a rate dependent upon the setting of a nee valve. At the end of travel as shown in *Fig.* 4, the bl

4—Right—Pneumatic timer employs hragm instead of conventional piston for timing up to three minutes

ates a precision switch controlling delayed timing or dwell period for operation required.

draulic dashpot time delay for re- ing a hydraulic feed pump is shown ection in *Fig.* 5. Although initial ation of the timer is governed by pressure in the system reaching a t preset by the adjusting screw, the sure in the system does not control movement of the timing piston. The mber below this piston is filled with which cannot escape until the plunger et actuates the pilot plunger. The e delay is selected by adjusting the e of the timing piston by a piston

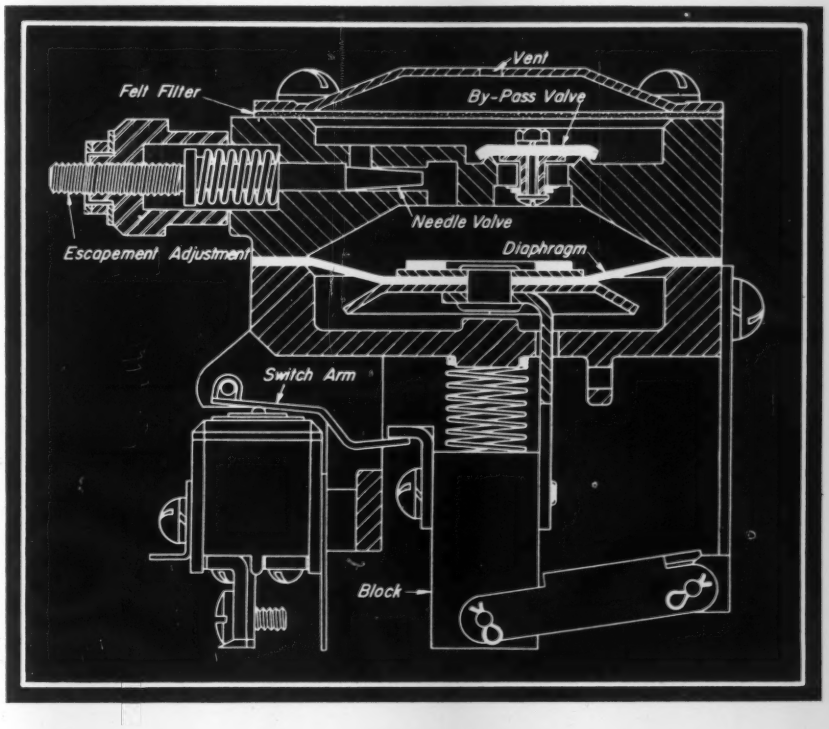
When electric remote controls are on feed pumps, variable time delays easily be obtained through the use a conventional time-delay relay. For ventional mechanical control of feed mps, the desired time delay may be ained through a time-delay relay and tandard solenoid-operated valve.

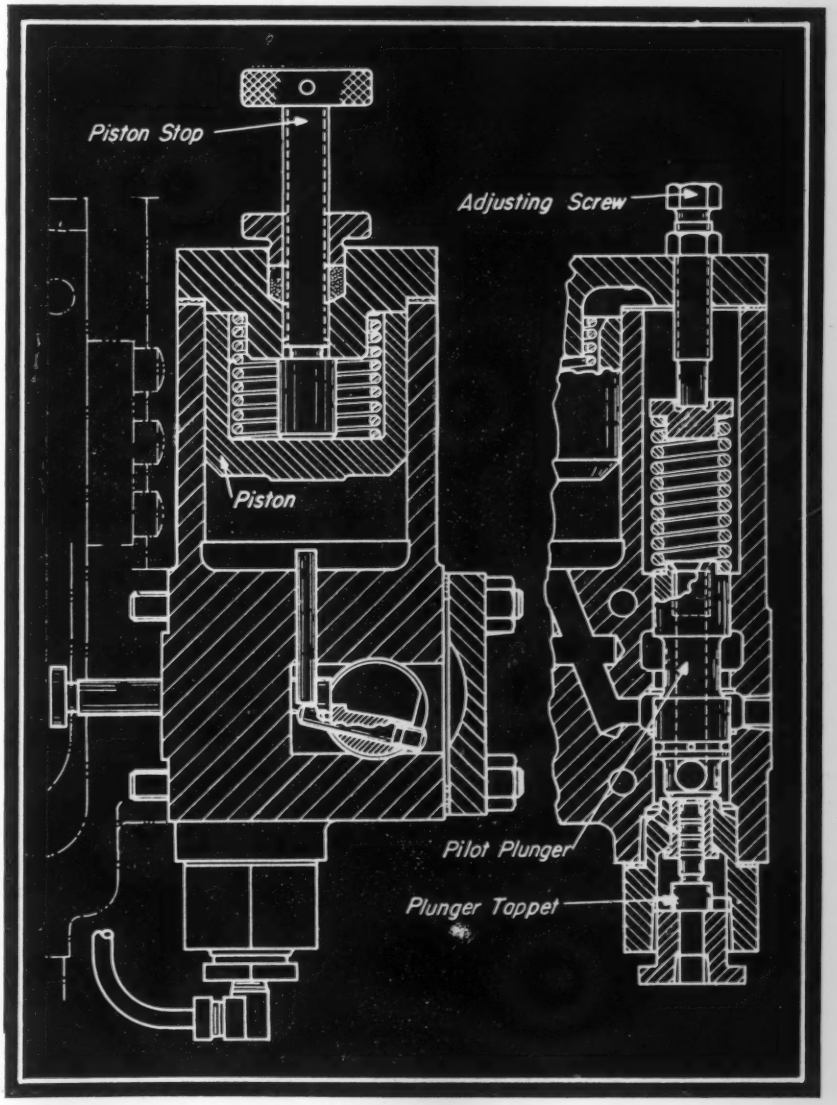
Years ago the majority of machine tools orporating delayed reverse controls re equipped with a small adjustable- ke control cylinder arranged to ac- te the control cam through a variable tance after the main head had stalled. is principle was not entirely satisfac- y because the time delay varied with volume of oil delivered by the pump well as the stroke through which the xiliary control cylinder was actuated.

Are More Accurate Than Dashpots

Thermal timers are generally either of e bimetal or melting solder types. For ce applications which do not re- ire extreme accuracy but rather more cise operation or longer timing than hpots possess, bimetal thermal units y be employed to advantage. A typi- example would be the preheating of aments in mercury-vapor rectifiers be- re the application of the plate po- tial.

Time-delay action is produced by a metallic thermostat built into a relay sembly. When current flows through an ctric heater wound around the thermo-





g. 5—Right—Sectional view of features dashpot. used for time delay in hydraulic circuits

stat, the increase in temperature actuates the bimetallic element, closing the relay coil circuit. Correction for changes in ambient temperature is accomplished by the use of an additional bimetallic element. Timing by this method is usually limited to between 3 seconds minimum and 360 seconds maximum.

Bimetallic time-delay relays are available with immediate self-recycling features. This requires an additional relay in the assembly. Another special type employs a heavy bimetallic unit to actuate a precision switch which in turn energizes the load relay. Such a unit, however, has a 120-second minimum delay because of the size of the bimetallic unit utilized in the relay.

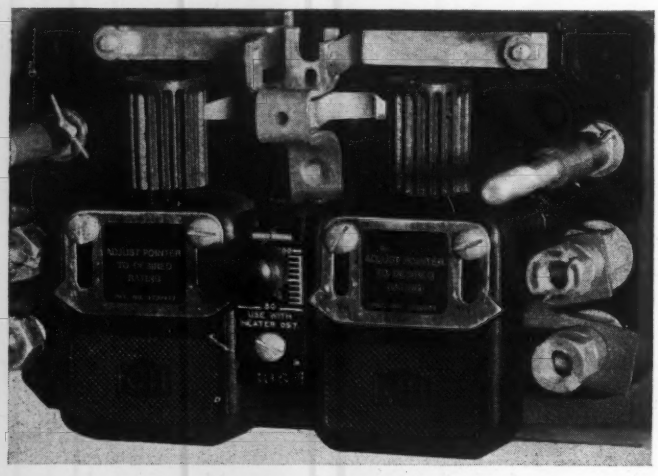
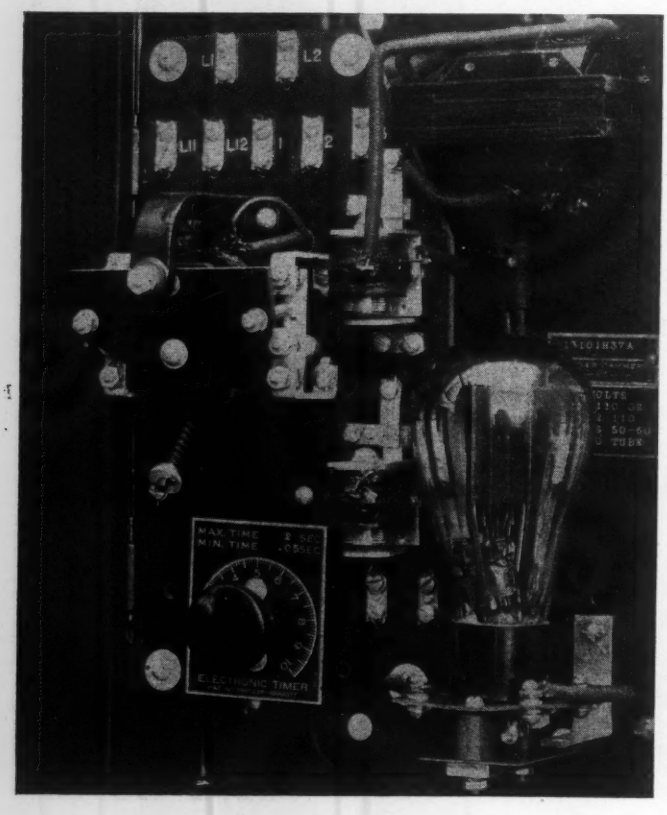


Fig. 6—Above—Melting solder type of timing unit used for overload protection

Fig. 7—Below—Condenser type of electronic timer for accurate timing between a few cycles and two seconds



Thermal units of the melting solder type are emp in a wide variety of overload relays. Actually, how many are used as time-protective devices to shut equipment in the event some automatic function i completed properly. Synchronizing of synchronous m or successful cranking of engine-driven generator set typical examples of applications.

Essential operating parts of the thermal unit for the shown in *Fig.* 6 are two heater coils, two solder t ratchet mechanism and tension spring. Under nor conditions the contacts are closed with the spring in sion tending to open the contacts. The ratchet mecha held by a solder film between an inner and outer she each tube, however, keeps the contacts closed. When current through either or both heater coils becomes g enough to melt the solder the ratchet mechanism is leased and the contacts open. As soon as the power cuit is opened the solder cools and the relay is ready t reset. Calibration is obtained by varying the positio the solder tube in relation to the heater coils, or by cha ing to heater coils of a different rating.

Capacity and Inductive Timers

Inductive time delay may be employed in electr circuits where delays of only a few seconds are des both for closing and opening contactors for hoist mo protection against circuit interruption during momen voltage drop, etc. This method operates on the princ that as voltage is applied to a circuit having inductance current will build up to its value at a rate dependent u the inductance in the circuit. Also as the voltage is moved the current will lag similarly. It operates on a n netic circuit with a small air gap, making the circuit hig inductive. Timing may be adjusted by increasing or creasing the air gap which changes the value of the cur at which the contactor will close.

Capacitor timing is based on the time lag in charg or discharging condensers to open or close a circuit. Wh multiple circuits are required to close or open in seque each condenser is paralleled with the coil of its succes relay so that the timing of each is independent of operation of the preceding circuit. Timing may be va by adjustment to about one or two seconds. Larger densers may be applied, however, to increase the time delay. Magnetic relays using condensers for timing utilized for acceleration of adjustable-speed motors, etc

Most electronic timers are based on the time requ to charge or discharge a condenser. They are widely u for resistance welders for accurately controlling curr flow. Such a timer, shown in *Fig.* 7, is adjustable from a f cycles to two seconds and is capable of reproducing ea successive interval at a given setting within ½ to 1 cycle.

Motor driven program timers utilizing cams or a dr with adjustable limits or stops for opening or closing cuits will be discussed in Part II in a later issue.

The helpful cooperation of the following companies in s plying the information and illustrations on which this article based is gratefully acknowledged: Allis-Chalmers Mfg. Cutler Hammer Inc., *Figs.* 3, 6 and 7; The Oilgear Co., *Fig.* Square D Co., *Fig.* 4; Walser Automatic Timer Co., *Figs.* 1 2; Ward Leonard Electric Co.

Electric Control Provides Accurate Response

By S. J. Mikina
Westinghouse Research Laboratories

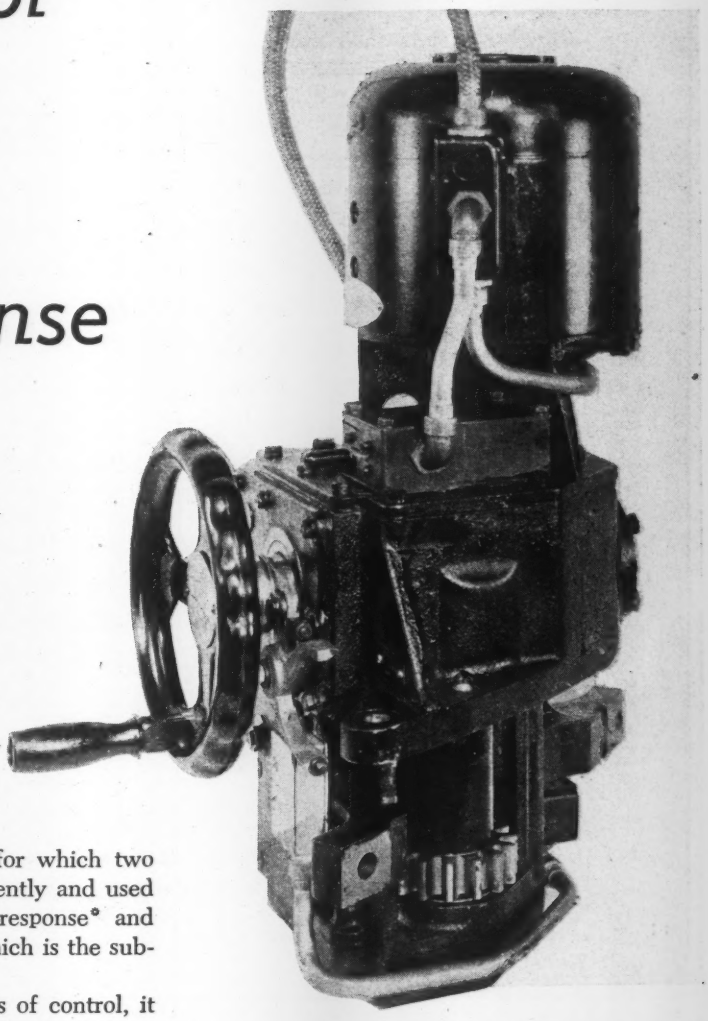


Fig. 1—Above—All-electric traverse unit for M-4 tank turret, showing control handwheel and turret drive gear

DEVELOPMENT of special controls for war machines and their proved success under rigorous conditions should furnish the basis many improved designs for peacetime application. A notable example is the tank turret control, for which two different types of mechanism were developed independently and used extensively. One was a hydraulic drive with velocity response* and the other an electric with positional response, *Fig.* 1, which is the subject of the present article.

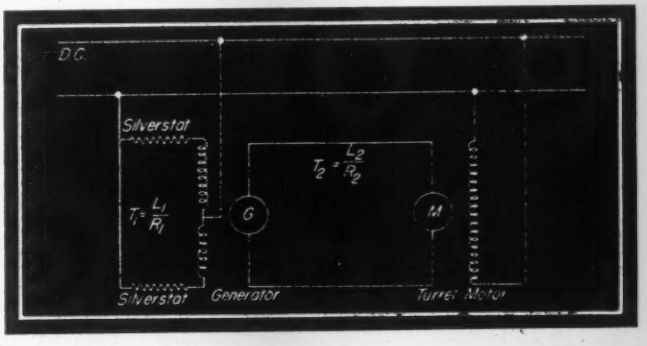
To make clear the distinction between the two types of control, it should be emphasized that in the velocity-type hydraulic control the turret angular *velocity* relative to the tank is proportional to the angular *displacement* of a control lever from its neutral position. As a consequence, there is no correspondence assured between the position of the control spade and the stopping position of the turret. If the turret is not in the desired position when the control has been returned to the neutral position corresponding to zero speed, then the spade must be momentarily deflected and returned to neutral a sufficient number of times to bring the gun sights "on-target". In the positional control under discussion, on the other hand, it was proposed to provide a continuously rotatable control handwheel and to cause the gun turret to follow this handwheel synchronously.

Equivalent to Effortless Mechanical Drive

Power drive thus would be made as responsive to the gunner's dictates as if he were manipulating an effortless manual drive, since the turret position would be proportional to the angular position of the control handwheel.

In a battery-powered tank turret, the variable-voltage direct-current system of control is the only one suitable for achieving the desired synchronous positional regulation with a minimum of electrical equipment and was accordingly adopted for use with the Silverstat type of rheostatic control. As shown in the schematic circuit diagram, *Fig.* 2, a resistance in either of two equal opposing fields of a direct-current generator running substantially at constant

Fig. 2—Below—Schematic diagram of variable-voltage direct-current drive



Abstract of a paper presented at the recent semiannual meeting of the American Society of Mechanical Engineers in Chicago.

*See the article, "Designing the Drive for the M-3 Turret", by Robert E. Becker, MACHINE DESIGN, March, 1945.—ED.

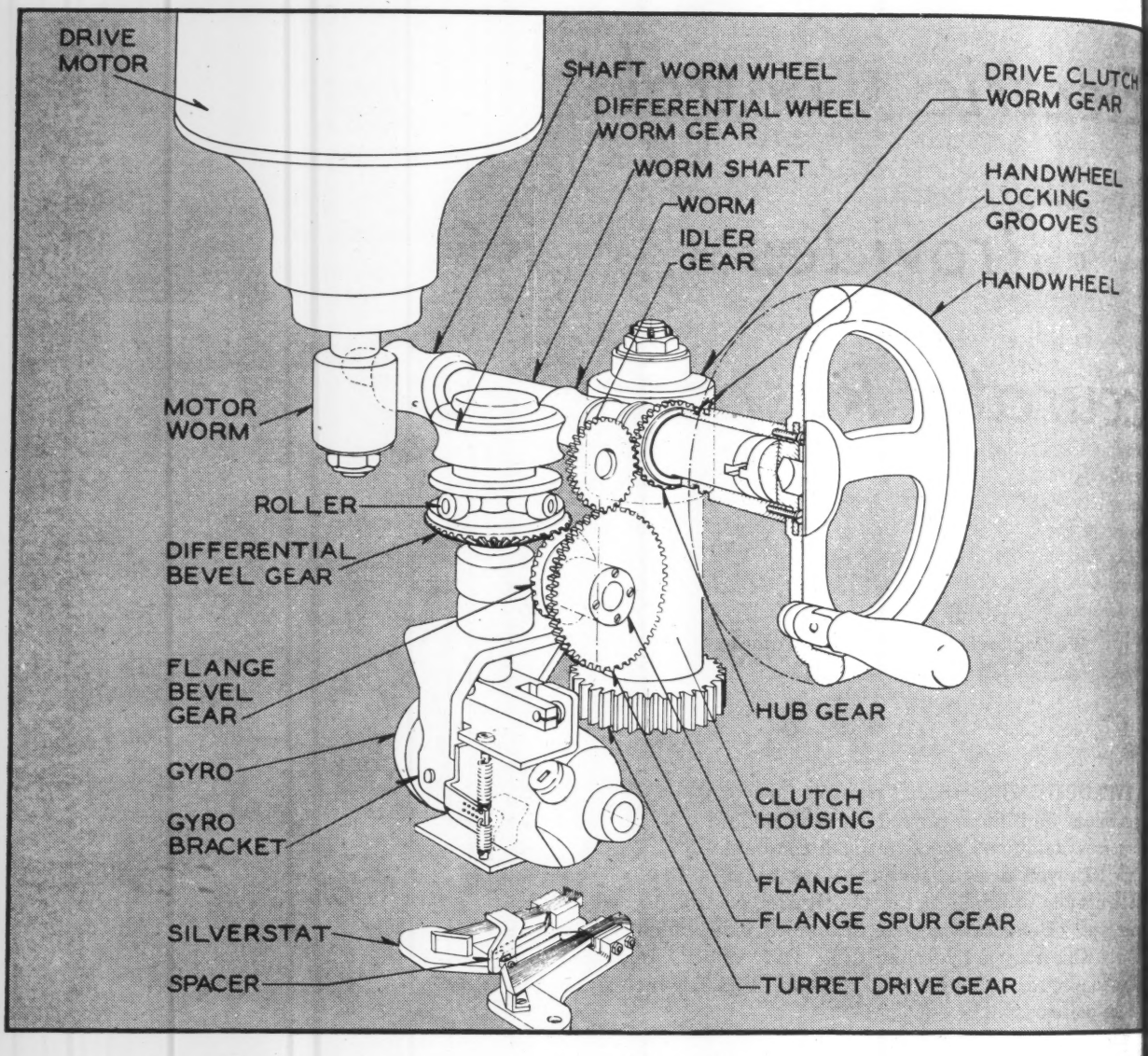


Fig. 3—Power train and control mechanism for tank turret traverse drive, including anti-hunting gyro

speed may be varied continuously to produce a generator output voltage also varying continuously from one polarity through zero to the reverse polarity. This output voltage may then be applied to the armature of a direct-current turret drive motor of constant field, to produce a corresponding variation in speed from a maximum in one direction through zero to a maximum in the opposite direction.

Roller Differential Provides Followup

To secure the desired proportionality between the control handwheel displacement and the angular displacement of the turret, the generator field resistance must be made to vary proportionally to the difference between the control handwheel or input displacement and the turret or follower displacement. For purely local control, as opposed to remote control, such proportionality between two positions may be realized most readily by means of a mechanical motion-comparison device such as a gear or roller differential mechanism which is capable of giving a shaft angular displacement proportional to the difference between the angular displacement of the connected handwheel and turret. The difference motion from the differential may then be utilized directly to vary the gener field resistance in such a sense as to produce torque the turret drive motor in a direction to reduce the differe motion to zero.

The foregoing expedients are a necessary, but not nec sarily sufficient, condition for securing synchronism tween handwheel input and turret follower motions. order to reduce the angular error between control ha wheel and turret to a minimum and to insure stable follo ing of the handwheel motion by the turret, suitable a hunting means must be incorporated in the control. In t case it was decided to employ gyroscopic anticipation compensate for time delays in the control system and th secure the greatest possible stability of regulation.

Having in this manner decided on the general schem of the drive, the next step was to embody these ide in a specific construction that would satisfy the pow requirements as well as the severe limitations on availab space in the turret.

Power requirements were calculated from a duty cy involving the operation of a gravity-unbalanced turret

n with the tank on a 30 per cent grade. The turret t was approximately 11,000 lb and its center of y was 6 inches from the azimuth bearing axis. This requires a peak horsepower of 1.2. To this must be d the horsepower required to overcome the azimuth g friction of the turret. For a 6-ft diameter ball bear- ace and a coefficient of friction of 0.01, the friction r is 0.25-hp. Taking into consideration the intermit- nature of traversing duty, as well as the fact that the unbalance load is further diversified by varying oidally with the turret azimuthal angle on the uphill of the cycle, the choice of drive motor boiled down rating of 1⅛ hp and 85 C for one hour when used drive gears having an efficiency of 85 per cent. Such tor can develop four or five times the full load torque ransient acceleration or other loads of short duration. eep the motor size within the turret space limitations, perating speed of 3700 rpm at rated load was en.

e comparatively high maximum operating speed of turret drive motor necessitated a gear reduction of t 900 to 1 from motor to turret. In considering the us possibilities for effecting such a speed reduction, prime objectives were kept in mind: (1) The desira- of combining the emergency manual drive with the r drive in such a way as to utilize the same gearing the same handwheel for both, and (2) avoidance of complication of a holding brake for either power or ual traverse, through the use of self-locking worm ing.

Attaining High Efficiency with Irreversibility

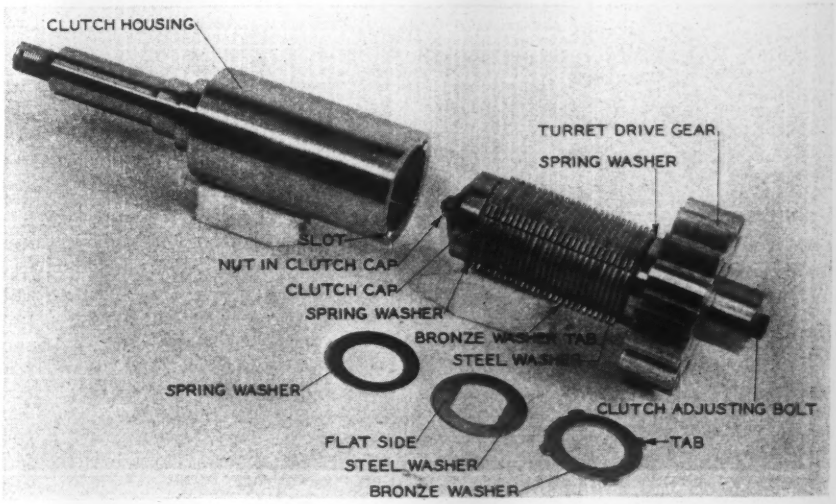
dvantages of the first objective are obvious from the dpoint of securing drive compactness and ease of ation. With regard to the second objective, it might n that the property of irreversibility in worm gearing is mpatible with high operating efficiency. That is not ssarily the case, however, since a worm drive may be versible at low speeds or at standstill when the coeffi- t of friction between worm and gear is high, but may me capable of high efficiency power transmission at her operating speeds as the friction coefficient is re- ed due to the development of a lubricating oil film ween the worm and mating gear. To ure low speed and standstill irreversi- y of the turret drive, there was, there- included a 20 to 1 worm gear re- tion with a lead angle of 5° in the r train between the electric drive or and the turret. Calculated effi- cy at higher speeds was 89 per t.

Complete gear train of the turret drive the M4 tank is shown in *Fig.* 3. The embly comprises the power trans- mission gearing and the control gearing for positional regulation of the turret. The power drive begins with the electric drive motor, which is mounted vertically to fit in the available space. The motor is provided with an initial 2 to 1 speed reduction consisting of a vertical eight-threaded reversible steel worm engaging a bronze gear at one end of a horizontal shaft. Next, an integrally machined worm on the horizontal steel shaft makes a further 20 to 1 reduction to the engaging bronze gear mounted on the upper end of the final drive shaft. Finally, a reduction of 22.4 to 1 is obtained between the drive pinion at the lower end of the final drive shaft and the internal ring gear on the tank hull. The overall ratio of 896 to 1 from motor to turret gives the latter a top speed slightly in excess of 4 rpm. The traverse unit is bolted to the turret and rides with it as the vertical drive pinion rotates relative to the stationary ring gear on the tank hull. The vertical drive pinion is clearly visible in *Fig.* 1.

Emergency Manual Drive Incorporated

Choice of the worm reduction gearing facilitated the incorporation of an emergency manual drive in the same unit. By mounting the control handwheel coaxially with the horizontal worm shaft it was possible to effect manual traversing simply by shifting the handwheel axially into engagement with drive slots on the end of the horizontal worm shaft. When shifting into manual drive, the power system is de-energized by a safety interlocking switch actuated by the handwheel shifting displacement, but it is not necessary to disengage the motor from the rest of the drive as it can readily be turned by the reversible eight-threaded worm gearing. The manual drive ratio of 448 to 1 from handwheel to turret is adequate for overcoming turret unbalance in a sloping tank without imposing excessive force on the gunner's hand. The ratio is high enough, moreover, to be useful for vernier sighting on distant targets from a stationary tank.

The horizontal single-threaded worm of the 20 to 1 reduction is irreversible within the limits previously defined, i.e., at low speeds and at stand-still, but this property of irreversibility, while useful for automatic load holding, makes it necessary to provide some means in the drive for limiting turret acceleration on stopping. Damaging decele-



4—Multiple-disk drive clutch which vents damage to drive resulting from too rapid deceleration of turret

rations, far in excess of what normally can be produced by the available drive torques, can occur on a sudden cessation or reversal of motor torque. The resulting rapid reduction in the worm velocity can bring the worm to a virtual standstill within the limits of its rotational backlash, while the turret is still near top speed. Immediate collapse of oil film lubrication and the development of irreversibility in the worm gearing makes it impossible for the turret to drive the motor, with the result that the kinetic energy of the turret can be dissipated only by severe deformation of the shafting, gearing, and gear case, accompanied by jarring vibration as the turret must of necessity come to a sudden stop against the unyielding self-locked worm.

This condition can readily be avoided by providing a slippable friction clutch in the drive system between the turret and the point of irreversibility in the gearing. A highly compact multiple-disk clutch was designed for this application and is shown in *Fig.* 4. The clutch is entirely contained within an enlarged portion of the final pinion drive shaft and consists of a stacked assembly of alternate bronze and hardened steel washers clamped together by a single central bolt extending through the axis of the stack. Pressure between the disks is maintained by coned-disk (Belleville) springs at each end of the stack and may be adjusted to vary the clutch slip torque by drawing the assembly together to a greater or lesser degree by means of the single central holding bolt. The clutch torque setting of 200 ft-lb is sufficient to bring the turret to a smooth stop from top speed in 4° at the turret, with stopping angles at lower speeds varying directly as the square of the turret speed.

A further consequence of the use of irreversible worm gearing is the possibility of occurrence of a low-frequency chattering or "stair-stepping" vibration of the drive system, albeit under somewhat infrequent conditions. Such a vibration can occur, for example, when the turret is being driven at low speed in the same direction in which an external load, such as the gravity unbalance on a steeply inclined turret, is urging the turret to go. Whenever found desirable to do so, the chattering can be eliminated by a simple increase in the inertia associated with the irreversible worm shaft.†

Associated with the drive mechanism for transmission of manual or motor torque to the turret is a system of gearing for effecting positional regulation of the power drive. This is shown in *Fig.* 3 to the left of the horizontal 20 to 1 worm shaft. The function of the control mechanism is to make a direct comparison of the angular displacements of the control handwheel and of the turret and thus produce an angular control shaft displacement proportional to the difference. This difference displacement is obtained by means of a differential mechanism and is used to actuate a pair of Silverstats for varying the resistance in the field of the direct-current generator supplying variable voltage to the traverse drive motor.

How Space Limitations Were Met

The particular arrangement of the control mechanism components shown was dictated by the available space limitations of the turret and represents the most compact design that could be devised. Thus, the manual traverse handwheel also serves for power drive control by being shifted into appropriate engagement with the control gearing. Similarly, a necessary 20 to 1 reduction in the follow-up gearing from the turret drive is effected by utilizing the same worm that serves the power drive, meshing it with a worm gear diametrically opposite the similar worm gear of the power drive. The height of the differential is reduced to a minimum by utilizing a pin and roller construction held in frictional engagement by compression springs.

In the initial design the control handwheel was fixed on an extension of the horizontal worm shaft as shown in *Fig.* 3. In later designs the handwheel was provided with a separate bearing to eliminate the slight disturbing effect of the oil film coupling between the worm shaft and

(*Continued on Page* 178)

†"Worm-Drive Jitters Can Be Avoided"—S. J. Mikina, MACHINE DESIGN, March, 1945.

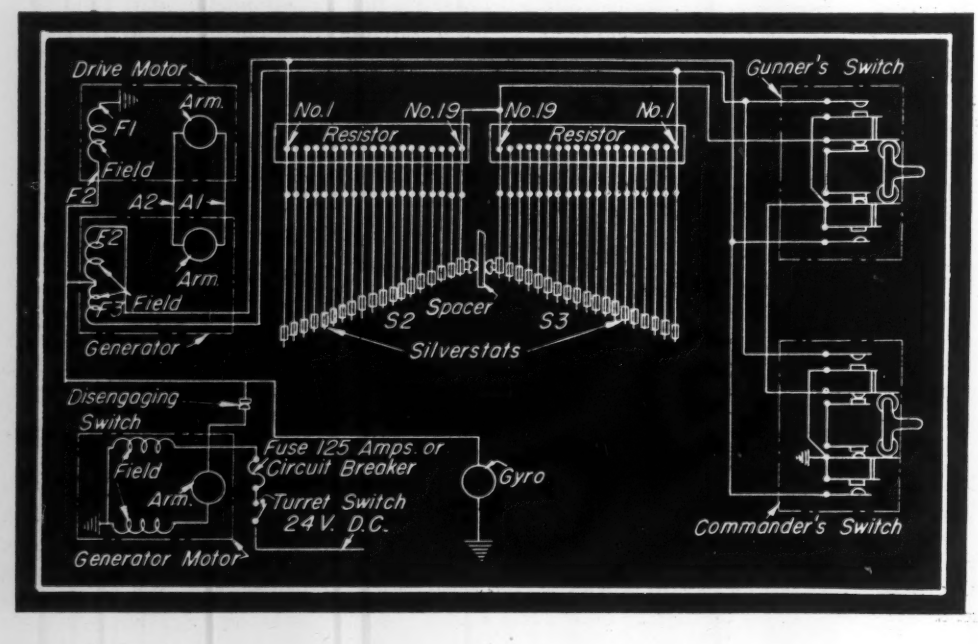
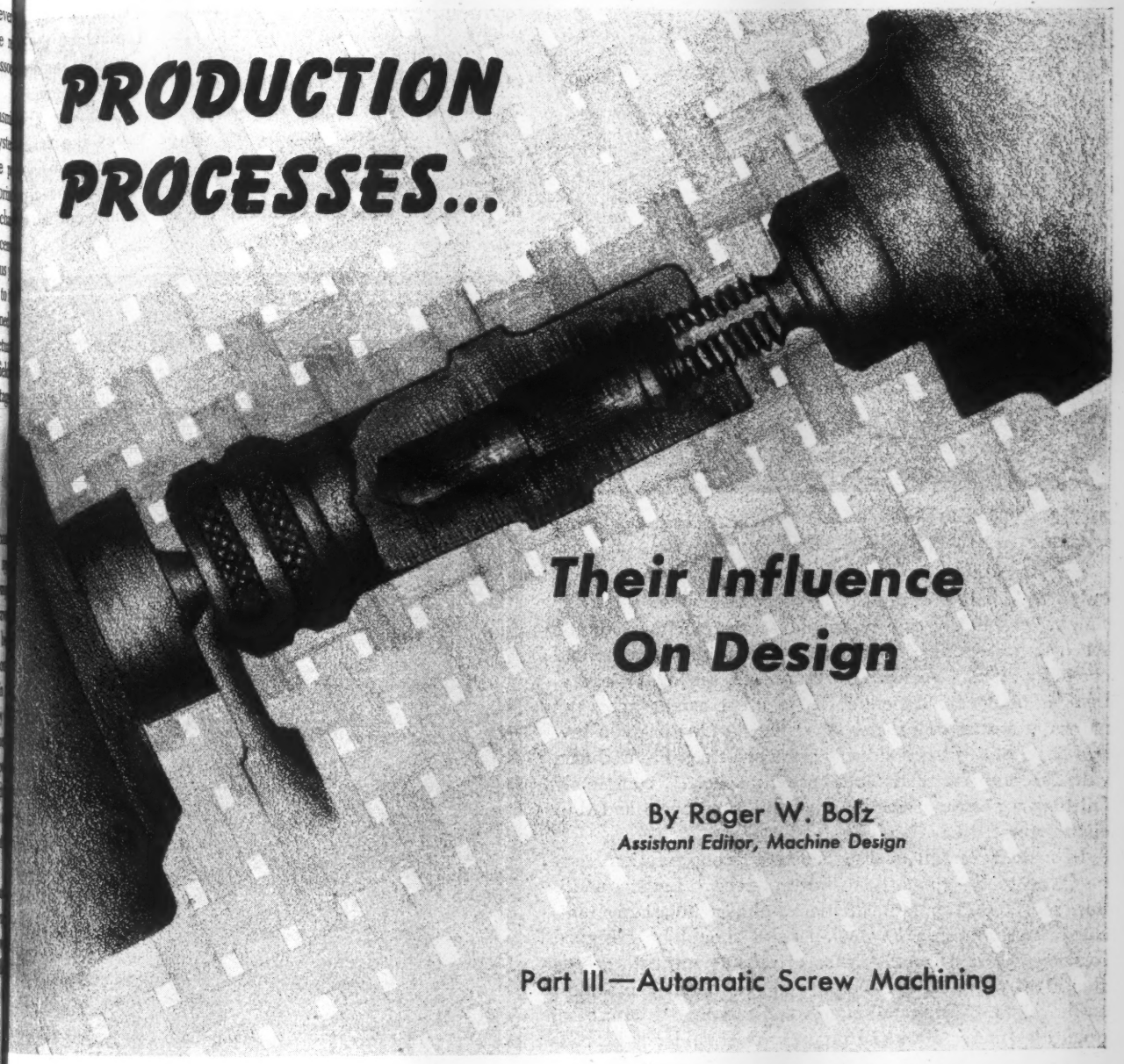


Fig. 5—Schematic wi diagram for tank t traverse. Comman switch cuts out gunn control when slewing turret on to a new ta



PRODUCTION PROCESSES...

Their Influence On Design

By Roger W. Bolz
Assistant Editor, Machine Design

Part III—Automatic Screw Machining

ADAPTED and originally designed for the rapid production of screws or threaded parts, the automatic screw machine—single or multiple-spindle variety —plays a vital role in the mass output of precision machine elements of both simple and intricate design. By no means limited to threaded parts, the wide range of possibilities afforded by this method of production both enhances its usefulness and makes imperative its consideration as a means of manufacturing machine parts which fall within its scope.

Capacity of present single-spindle machines ranges from ⅛-inch to 8-inch diameters and lengths up to 8 inches. One special model will handle diameters up to 10½ inches, Fig. 1. However, the major portion of these machines in common use fall into two general classes, one limited to 2½-inch and the other to 1-inch maximum diameter stock. Lengths of parts are limited to 6 inches maximum. Multiple-spindle machines can handle bars up to 5 inches in diameter with some parts as long as 20 inches. Those in common use, though, are limited to parts up to 2⅝-inch diameter and 6 inches in length. Minimum diameter limitations are necessarily hard to define since large machines can also handle small diameters and short lengths, but as a rule these large machines are likely to be somewhat less economical for small parts and normally are used for parts ranging in the larger diameters. Single-spindle machines can be used most economically for parts ranging from ¼-inch to 1-inch in diameter when runs are short. Parts should, as a rule, fall within the diameter and length limitations of the machine in mind. However, in some cases, maximum length can be exceeded by using special tooling so long as the work does not exceed the power capacity of the machine. It is advisable to consult the manufacturer on such jobs to assure a reasonable cost economy.

Most machines are capable not only of producing parts involving forming, facing, drilling, threading, reaming, burnishing, knurling and like operations at an extremely rapid rate, but in addition such machining operations as slotting, milling, burring, end threading or cross drilling also can be produced without any appreciable loss in the rate of

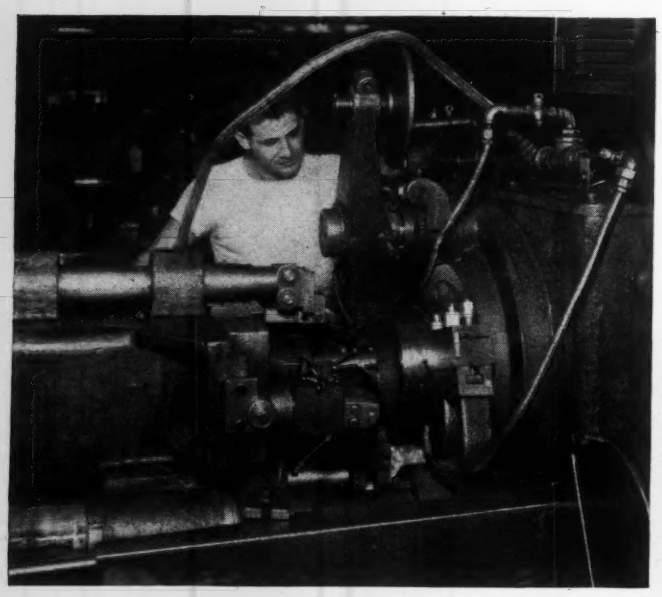


Fig. 1—Above—Probably the largest automatic screw machine used today, this model handles 10½-in. stock

output. Where these secondary operations are relatively simple, practically any available screw machine can be set up to perform them without disturbing the normal cycling period. Advantageous use of secondary operations is of course dependent to a great extent upon the nature and number of such operations. One or even several accurately spaced slots or cross holes can be produced with the proper attachments (usually special), completely finishing a piece within the allowable time cycle and thus eliminating further handling.

In arriving at an overall economy, consideration must be given to the quantity to be produced. Large quantities, say 50,000 or 100,000 parts, almost invariably indicate a multiple-spindle machine and should be designed for such. Small-quantity runs of not too intricate design should in every case be produced on the machine most easily set up—usually a single-spindle type. In any case, quantities under 1000 parts generally should not be considered for automatic production because it is seldom economical unless further sizable orders for the same part are expected. Tooling costs for small quantities are usually prohibitive and the parts can be produced readily by other methods at less expense.

DESIGN: Wherever a design can be altered without affecting the normal planned function of the part to decrease the number of or the time required for the various operations necessary to produce it, total cost per piece can be reduced materially. As is recognized readily, the simplest of shapes are reproduced most easily and naturally require the minimum in tooling. In maintaining plicity of design, especially in external machine fit good form from an artistic standpoint is equally impor in sales appeal. Relatively simple forms can be fini completely by a single form tool, *Fig.* 2, so long as length of cut does not exceed three times the sma formed diameter of the piece. Longer forms usually quire two or more forming tools, each completing a tion of the contour. Naturally the outermost cut is

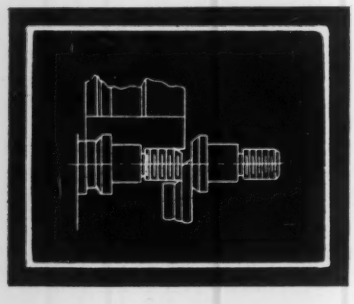


Fig. 2—Simple forms can be finished with one tool when the length is not too great

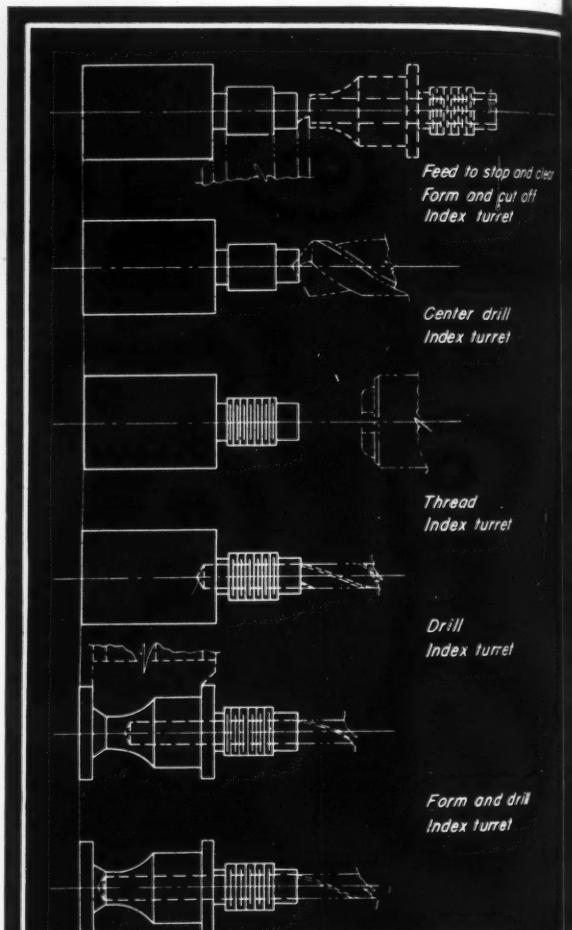


Fig. 3—Long forming cuts require a set of several or m forming tools, finishing the outer surfaces first

first, assuring minimum deflection, *Fig.* 3. Such co binations increase tooling costs somewhat but are n ligible in large production runs. It is good practice provide a straight cylindrical portion at the outer end o part for the use of a roller rest to enable faster forming longer tool life.

Perfectly square or undercut shoulders can be produc but wherever possible should be eliminated in favor o slight taper, *Fig.* 4. Tools to form a shoulder as sh necessarily require a side clearance in order to produc smooth finish. Those designed to make a perfectly squ shoulder usually leave a poor finish and drastically shor tool life thereby increasing the cost. Shoulders stepp in one direction only can be made square with little eff

verall cost. Where shoulders must be square and the not overly complicated, a finish squaring operation be used in the tooling set-up without affecting the However, unless required and specifically indicated uare, form tools for shouldered parts are made with sitive angle, usually a minimum of one degree for a w cut to three degrees for a deep one. This allow- will, in nearly all cases, still maintain normal toler- required and at the same time produce a commer- acceptable surface finish. Undercut shoulders, of e, require an extra tool or a special attachment.

les, wherever possible, should be shown with a stand- rill point at the bottom, *Fig. 5a,* for maximum econ- If flat bottomed holes, *Fig. 5b,* or square shoulders epped holes, *Fig. 5d,* are deemed necessary, a sec- y or squaring operation usually is required. Tool- an be simplified by providing allowance for a drill at the center of a blind hole, *Fig. 5c,* and a tapered on through holes, *Fig. 5e.* Shallow flat-bottomed can be produced easily with simple tooling such as terbores, etc. Holes 4½ to 5 times their diameter in can be produced in one operation. Holes of lesser are of course more economical. By utilizing more one station, total hole depth ordinarily can be in- ed to 8 times the diameter and at the greatest ten. r maximum economy American National Standard ds always should be specified, the fine series of this dard being the most satisfactory. A minimum of ma- is removed in cutting fine threads and consequently mum threading speeds can be employed. Fine threads be run up closer to a shoulder than the coarser ones, me cases safely within 1½ threads, *Fig.* 6. On ordi- threaded parts, *Fig. 6b,* shoulder clearance "*A*" should least equal to 2½ threads in length for maximum ease et-up. If the part must screw down tight the neck ld have an undercut, *Fig. 6a,* at least 2½ threads in h. Neck diameter at "*A*" should be about 0.010-inch r the minor diameter of the thread.

se of proper chamfers or throat on threading dies ma- lly increases die life and improves the thread finish iderably. *Fig.* 7 shows the approximate number of ads affected by various angles of chamfer. The 30- ee, 1½-thread chamfer is recommended and used for cutting steel or brass; the 20-degree, 2-thread cham- is preferred for machine steel and alloy steels; the 15- ee, 3-thread chamfer is used extensively for tool steels

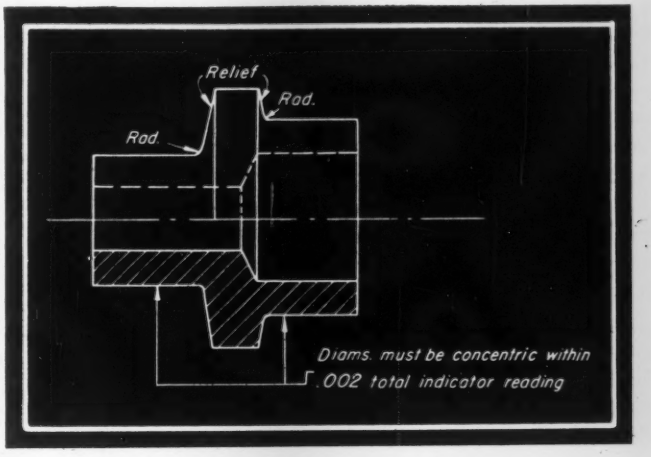


Fig. 4—Above—Forming tools require a positive side clearance to assure smooth finish

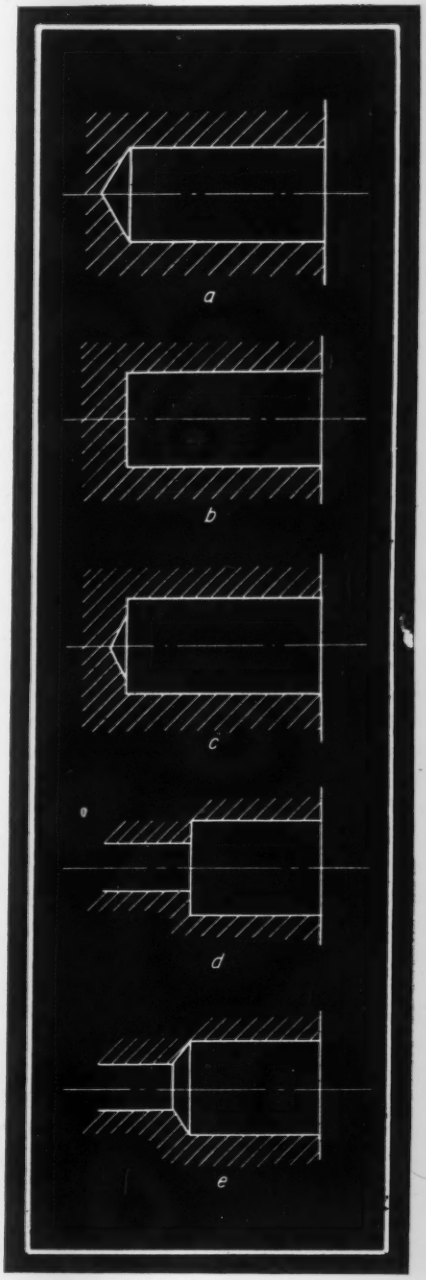
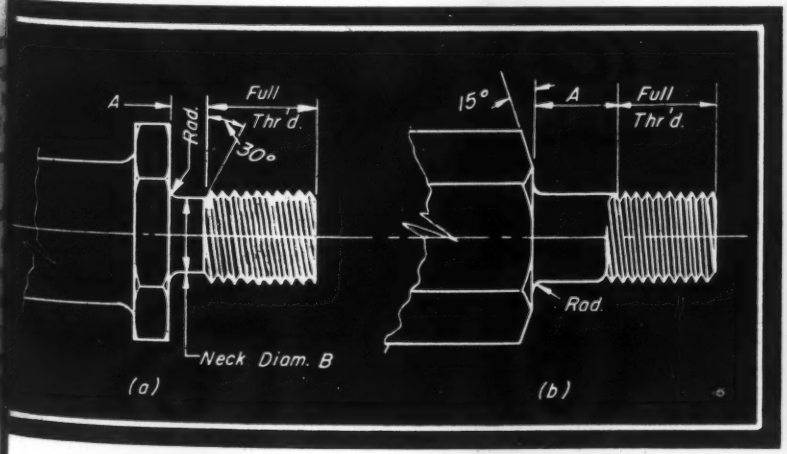


Fig. 5 — Right — Holes as shown at **a**, **c** *and* **e** *are more economical to produce than those at* **b** *and* **d**

Fig. 6—Below—A clearance A of at least 2½ threads width is required for economy



and other tough steels. Where threads necessarily must be cut close to a shoulder, the 40-degree, 1-thread chamfer is used (usually a finishing die).

Specification of tapped holes also demands special design considerations. Blind holes, *Fig.* 8, require plenty of chip clearance. As shown at "*A*", chip clearance should be equivalent to 5 threads in length (minimum) to allow the use of a standard tap. Otherwise, unless the hole is drilled through (which is preferable), a special secondary bottom tapping operation with somewhat inferior finish must be used to enable tapping within a 3-thread clearance. Where parts must thread and seat to a flat bottom, *Fig.* 9, a recess must be provided with a width of at least 3 threads. The minimum diameter of the recess should be 0.010-inch greater than the major diameter of the thread and limits must be wide.

The required number of full threads always should be specified. A length of 5 full threads usually is allowed as a bare minimum for assuring sufficient strength. Leading threads on both male and female work should be chamfered to assure good entry and centering in machining and to eliminate burrs. Good practice is to countersink 0.020-inch over the major diameter of a tap and chamfer 0.020-inch under the minor diameter of the die with an included angle of 90 degrees.

In many cases with parts such as that shown in *Fig.* 10, it is found desirable to complete the entire part in the automatic to obtain lowest cost per piece. When attachments are available, threads situated back of a shoulder can be rolled if nonferrous materials are specified. Otherwise a secondary operation usually is necessary. An undercut as shown is advisable for rolled threads to eliminate the burr normally thrown up in rolling.

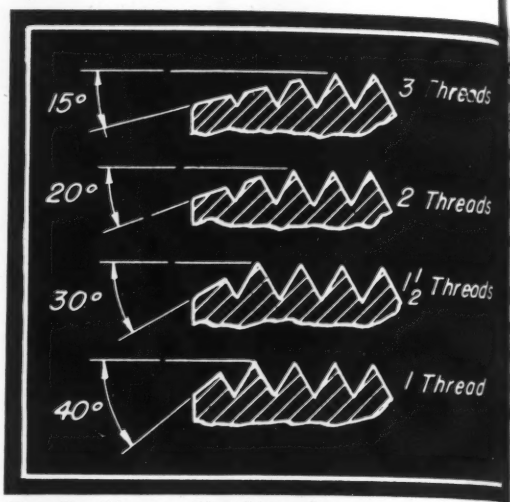


Fig. 7—Above—Shoulder clearance in threading affected by the chamfer of the tap or die. above are usually used as noted in the text

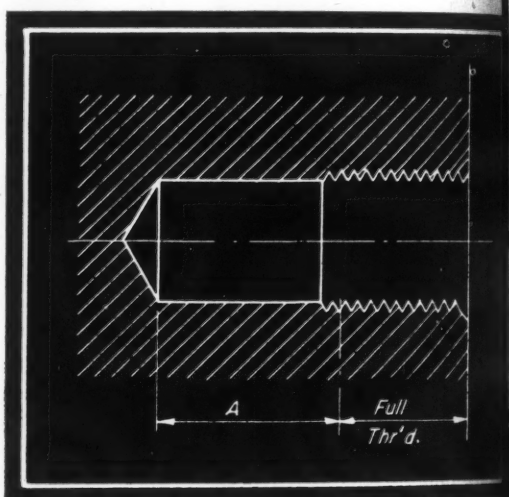
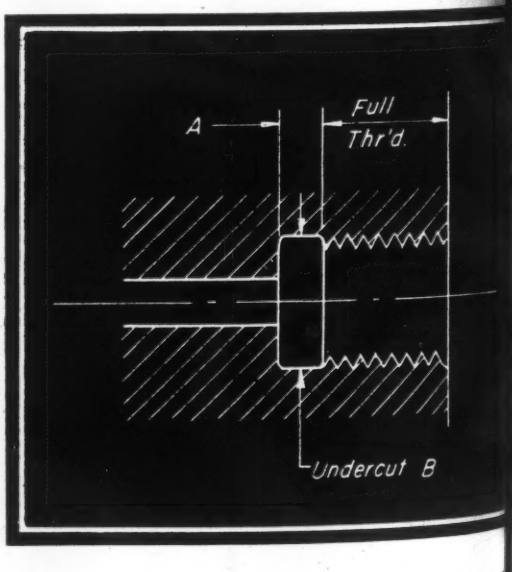


Fig. 8—Above—When tapping blind holes plenty chip clearance is necessary to avoid tap breaka

Fig. 9—Below—A recess usually is recommen when the male threaded part must bottom and



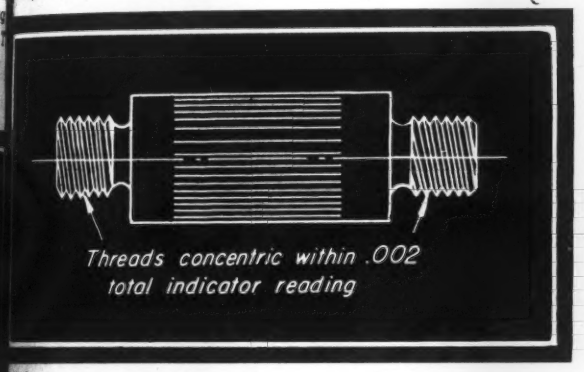
Long Slender Parts a Problem

Long or short tapers are relatively simple to produce as long as the small end is unobstructed by shoulders, etc. When this condition exists, long tapers readily can be machined with hollow mills, balanced or box tools. However, where the taper is reversed or behind a shoulder, forming tools are necessary and can be used only where the minimum turned diameter is sufficiently strong to resist deflection or breakage. Since ordinary forming tools produce the smallest diameters simultaneously with the largest, long slender parts with reverse tapers or irregular shapes cannot be satisfactorily formed. Such parts, *Fig.* 11, are usually produced in brass or other soft materials with a skiving tool which forms the largest diameters or ones farthest from the chuck first, supporting the finished surface as the cut proceeds. In other metals a swing tool is utilized to generate the form using a support or steady-rest to obviate spring in the material. However, swing tools cut more slowly than form tools, hence designs requiring their use should be employed sparingly. Tapers should be specified as standard machine tapers in order to utilize standard tooling and thus permit maximum economy.

Corner and edge radii should never be less than 0.005-inch. Generous fillet radii or chamfers at all intersections help to lower tool costs materially and strengthen the parts. Chamfers are preferred to rounded corners and are far less expensive to produce. If cut-off burrs on solid or hollow parts will be detrimental either to appearance or function of the part, they should be removed. However, where they can be tolerated, the extra burring or chamfering operations can be eliminated.

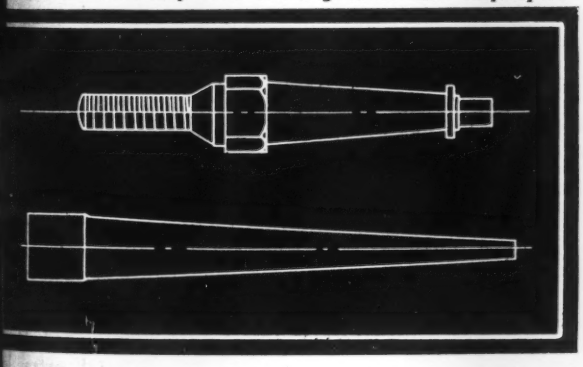
Knurls for appearance, grip surfaces, press-fitted joints, anchor holds for inserts, etc. can be applied to any outside diam-

surface, *Fig.* 12. Open-end knurls or those that can produced by feeding in from the turret along the axis e part are perhaps the most economical and easiest to duce. Those located in recesses or behind shoulders t be formed by a cross slide or swing tool and, consently, total width of knurled surface is limited. The h of knurl should never exceed the diameter of the led section. Raised type knurls usually are specified secure grip surfaces, press fits, and anchored parts e the depressed or female type is used only on parts iring a small amount of roughness on narrow widths re the turned stock diameter must not be exceeded. rawings of knurled parts should, for uniform quality, ify the type and pitch of the knurl desired as well as diameter of the section either before and after knurl- preferably before. Types shown in *Fig.* 12 are pro-



10—Above—To complete this part in the automatic d retain tolerances shown thread rolling is used

11—Below—Long slender parts such as these cannot ormed successfully and skiving tools are employed



d in standard pitches ranging from 16 to 62 teeth per . Included angle of the knurl teeth is of value in deining the diameter before and after knurling. An inled angle of 90 degrees works most satisfactorily on materials such as brass and hard copper; 80 degrees ecommended for iron; 70 degrees on wrought iron and hine steel; and for tough materials such as drill rod and steel an angle of 60 degrees is most efficient. Diam- increase due to knurling will be approximately .4 nimum) to .7 (maximum) of the depth of knurl tooth ulated from the included angle.

a manner not unlike the knurling procedure, names, marks, number identifications, etc., can be impressed external cylindrical surfaces of parts. Although a ial marking tool is necessary, set-up to utilize this feature of the automatic usually results in a substantial saving over other methods of marking by separate handling.

If the generally accepted commercial finish left by forming tools, drills, etc. is not satisfactory for any reason, better surface finish can be obtained but at increased cost per piece. External surfaces can be skived or shaved after forming and internal surfaces can be reamed. However, if still smoother finish is essential, burnishing can be resorted to as an added operation. Change in dimensions after burnishing is extremely slight, the process merely rolling over and smoothing out tool marks by cold-working. Where burnishing is not feasible, grinding may be specified to obtain the desired finish.

TABLE I*

Comparative Machinability Ratings of Various Cold Drawn Bars for Screw Machine Use

Screw Machine Steels	
SAE 1120 (leaded)	140
SAE X1112	140
SAE 1112	100
SAE X1314	90 to 95
SAE X1315	90 to 95
SAE 1120	70 to 75
SAE X1335	70 to 75
SAE X1350	70 to 75
Carburizing Steels	
SAE X1020	50 to 65
SAE 1025	50 to 65
SAE 1020	50 to 65
SAE 1015	50 to 65
SAE 6120 (annealed)	45 to 50
SAE 6115	45 to 50
SAE 3115	45 to 50
SAE 4615 (annealed)	45 to 50
SAE 2315 (annealed)	45 to 50
SAE 3215	45 to 50
Heat Treating Grade Steels	
SAE 1035	55 to 60
SAE 1040	55 to 60
SAE 1045 (annealed)	55 to 60
SAE 4130 (annealed)	40 to 50
SAE 4140 (annealed)	40 to 50
SAE 3140 (annealed)	40 to 50
SAE 6135 (annealed)	40 to 50
SAE 6140 (annealed)	40 to 50
SAE 6150 (annealed)	40 to 50
SAE 1335 (annealed)	40 to 50
SAE 1350 (annealed)	30 to 40
SAE 2330 (annealed)	30 to 40
SAE 2345 (annealed)	30 to 40
SAE 3140	30 to 40
SAE 2345	30 to 40
SAE 52100 (annealed)	30 to 40
Stainless Steels	
Iron, free cutting (14 per cent Cr)	60
Steel, 18-8	30
Steel, free cutting 18-8 (annealed)	50
Nonferrous Metals	
Magnesium Alloys	500 to 2000
Aluminum Alloy 11S	500 to 2000
Aluminum Alloy 2S	300 to 1500
Aluminum Alloy 17S	300 to 1500
Brass, leaded	150 to 600
Brass, yellow	200
Brass, red	200
Bronze, lead bearing	200 to 500
Gun Metal	60
Bronze, manganese	40
Nickel	20
Monel Metal	45
Bronze, silicon	60

*American Society for Metals.

Values are for operations, such as turning, forming, drilling, threading, and cutting off using high speed steel tools and conventional cutting fluids. Ratings are based on a value of 100 for Bessemer screw stock, SAE 1112, using a cutting speed of 150 fpm. "Annealed" indicates bar was annealed before cold drawing. Otherwise bars are cold drawn from the hot-rolled condition. Values are only indicative and will vary somewhat with conditions and operations.

Particularly smooth, accurate threads sometimes are a necessity. These usually can be obtained by means of an extra finishing operation. A roughing tap from 0.010 to 0.015-inch undersize or a roughing die 0.010 to 0.015-inch oversize usually is employed. The light finishing operation results in a much smoother thread.

MATERIALS: Naturally, materials which afford easy machining at maximum speeds provide the lowest cost

parts and least expensive tooling. Free machining brass is perhaps the most widely used material for general purpose parts, especially those requiring an electroplated finish. Regardless of the high cost of brass stock, the extremely rapid rate of production coupled with the high return on brass scrap many times results in lower overall cost per piece. Free machining cold-rolled or cold-drawn Bessemer screw stock, SAE X1112, (AISI B1113), should be specified wherever and whenever design in steel permits. Highest in machinability of all the steels, this stock usually results in a minimum overall cost per part owing mainly to excellent finish and rapid cutting speeds. Where corrosion resistance is imperative and plating unsatisfactory, stainless steel of the free machining variety can be used but at some loss in output. Aluminum and magnesium alloys probably offer the maximum in machining speed where design is not too complicated. TABLE I shows the machinability ratings for some of the more common metals based on a 100 per cent rating for SAE1112 steel.

Where hollow parts are relatively large, steel tubing stock sometimes can be utilized to advantage. Stock removal and boring operations are minimized, effecting considerable economy in time and material. In nonferrous materials even small sizes of tubing can effect worthwhile economies. Special extruded or drawn shapes often can be used with special collets to eliminate secondary operations.

TOLERANCES: Specification of tolerances smaller than necessary inevitably reduces the maximum speed of production with resultant needless expense. Ordinarily, single-spindle machines are credited with the ability to work within closer limits than the larger multiple-spindle types where accuracy of spindle spacings and bearing fits are more critical. However, in commercial practice, limits of plus or minus 0.002-inch commonly are held on decimal dimensions for diameters up to 1-inch, plus or minus 0.003-inch on diameters up to 2-inch, and plus or minus 0.005-inch above 2-inch. Lengths from shoulders to other p
finished with form tools can be held to plus or minus 0.
inch. Diameters specified in fractions usually are he
plus or minus 0.005-inch and on lengths to plus or m
0.010-inch. Naturally closer tolerances can be held
some dimensions where it is essential. Shaving tools
often be resorted to in such cases. For delicate parts
inch in diameter and under, requiring extremely close
erances, a Swiss type automatic rather than the reg
single or multiple-spindle types is the most likely mac
for the job.

Drilled holes up to ⅜-inch ordinarily are produced
commercial limit of plus 0.003-inch and minus 0.002-i
Larger holes require greater limits depending on the de
Smaller tolerances require an extra reaming operation
ordinarily an overall tolerance of 0.002-inch can be h
Closer tolerances than 0.002-inch usually require
rough and finish reaming operations.

Limits Sometimes Reduce Production

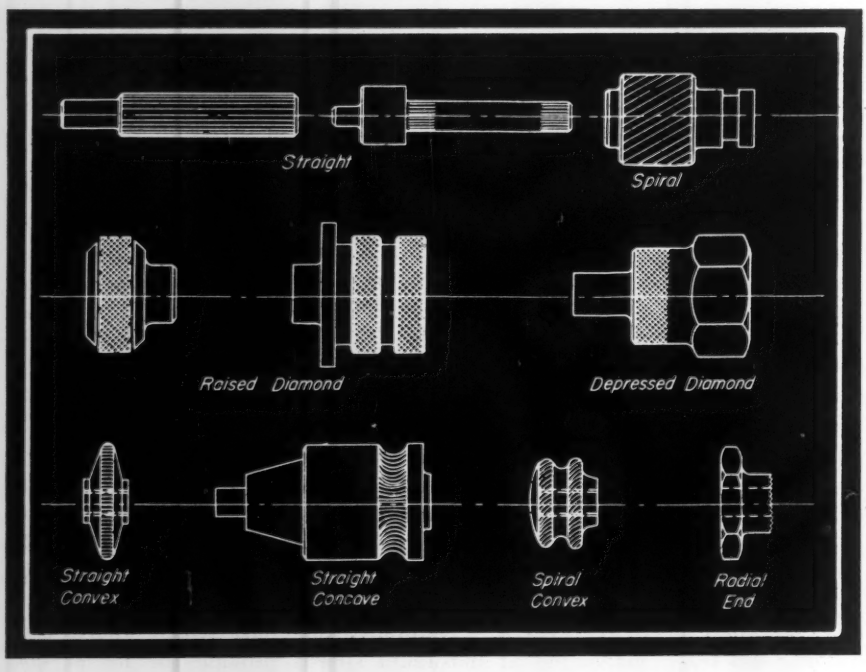
Concentricity limits of plus or minus 0.005-inch usu
are maintained between drilled holes and turned di
eters where the holes are not excessively deep. Wh
two sctions of a part or two threads, *Fig.* 10, must be ma
tained to less than this, special set-up is necessary.
this case, both thread blanks are formed at the same ti
shaved, the first thread cut, and the rear one cut or m
to hold the required limits. Set up obviously is more co
plicated and production reduced by the limits impo
The concentricity limits shown on the part in *Fig.* 4 m
impractical the procedure which normally would be u
and makes necessary the forming of both diameters
multaneously on a larger machine.

Taper angles in commercial practice are held to plu
minus one degree. Smaller limits can be maintai
where essential however, especially on parts which
be produced with a forming or t
reaming tool.

Fractional thread lengths un
otherwise specified are held to p
or minus one thread. Unless
somewhat increased cost of produc
and holding class 3 limits or even
greatly increased cost for class 4 lim
are warranted, class 2 (general pr
tice) fits are recommended for
screw threads. Special extra l
threads should have pitch diame
limits increased according to
American National Screw Thre
Standards to account for additio
lead errors and insure proper engag
ment otherwise a special lead scr
attachment must be utilized.

Collaboration of the following orga
ations in the preparation of this ar
is acknowledged with much appre
tion: Brown & Sharpe Co.; Burgess
Inc.; Eastern Machine Screw Co
Timken Roller Bearing Co. (*Fig.*
Weatherhead Co., The Burgess Co.
was particularly helpful in providing p
tical manufacturing background mate

Fig. 12—Various types of knurls are used for appearance, grip surfaces, press fitted joints, and anchor holds for inserts



Special-Shape BAR—

What It Offers the Designer

By Richard K. Lotz
Associate Editor, Machine Design

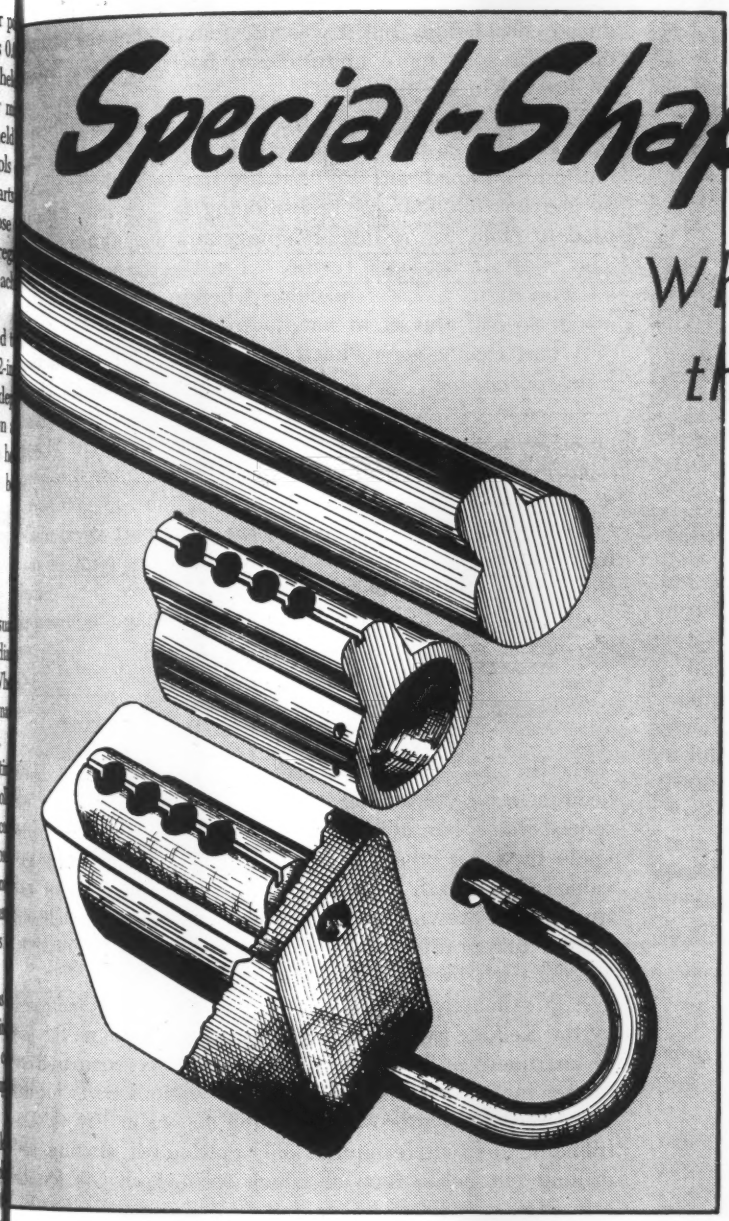


Fig. 1 — Above — Sleeve of pin tumbler padlock, formerly a casting, now is cut from special-shape bar stock

COMPETITION in the field of machine manufacture during the postwar period promises to be keener than ever before. Thus, it becomes increasingly imperative for the machine designer to keep a sharp eye cocked toward any and all expedients that might help to produce satisfactory machine parts at lowest possible costs.

It is of course no secret that the less machining and handling a part requires, the more economical will be its production. While there are many production processes that offer either drastic reduction or complete elimination of requisite machining—one might cite die and permanent-mold casting, stamping, forming, and powder metallurgy—this present article will be devoted specifically to the use of special-shape bar.

These special-shape bars offer, in effect, what might be termed "partial fabrication" inasmuch as they constitute a bar stock that is formed along one axis to the shape of the finished part. Generally, forming of the bar is effected either by extruding or extruding followed by cold drawing. The principle of extruding, similar in all cases, involves forcing a billet of heated metal through a die of the desired cross section. By cold drawing the extruded bar to final shape and dimensions the metal is cold-worked and, in consequence, the physical properties of the bar are appreciably improved. Differences between the properties of various familiar steels as hot rolled and cold drawn will be noted in the table "Typical Properties of Hot-Rolled and Cold-Drawn Carbon Steels".

It becomes apparent then, that use of

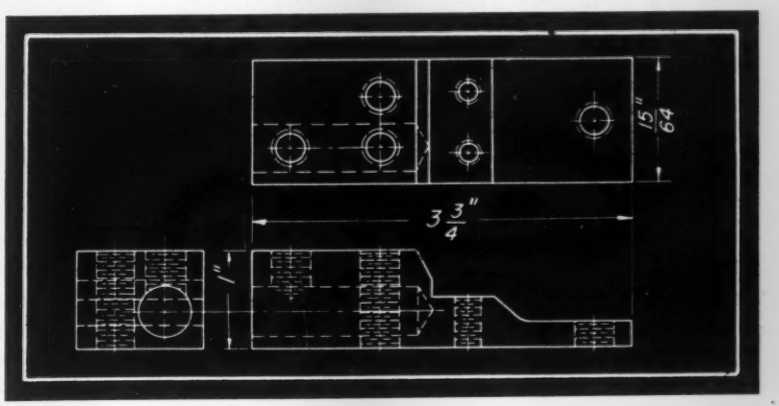


Fig. 2—Right—Production of this contact base from special-shape bar reduced costs

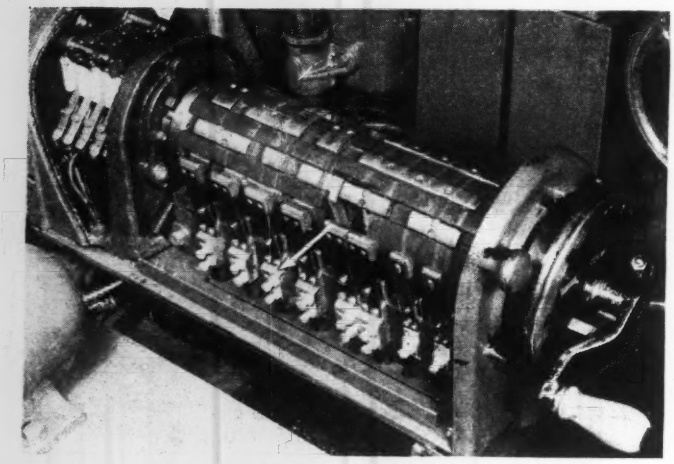
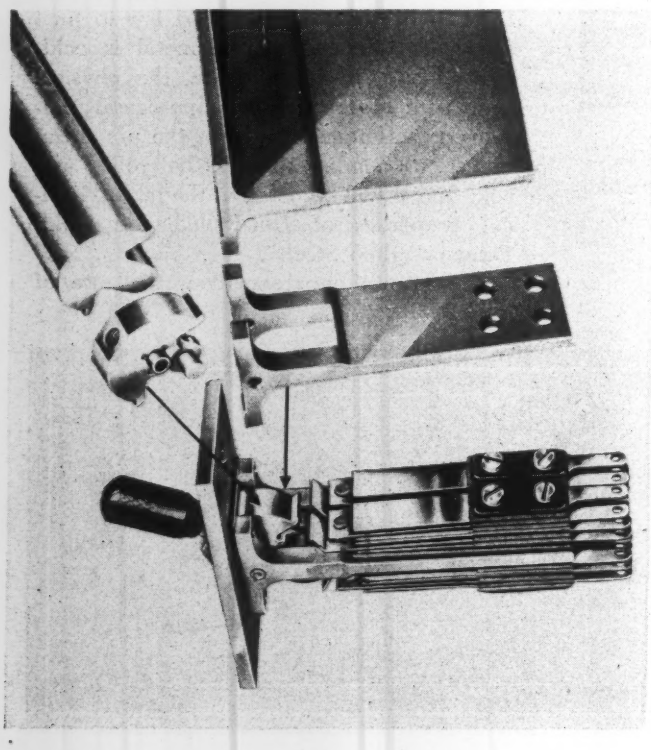


Fig. 3—Contact base of Fig. 2 is shown here (arrow) in position on final assembly of locomotive controller

special-shape bars can offer not only cost savings but, in many instances, result in parts having better metal structure than is normally obtainable by other production processes. A case in point is the sleeve for a pin tumbler padlock, *Fig.* 1, made by E. T. Fraim Lock Company which reports that production of the sleeves from shaped brass bar has cut labor costs on the parts by 50% and, in addition, has made possible a production increase of 300% over that experienced previously with sand castings. Seven machining operations, required on the sand castings, were no longer necessary on the blanks cut from the extruded and drawn shaped bar. These included cutting off, gateing, sanding, box milling, and three standardizing operations.

° An article dealing more extensively with this phase of the subject is planned for publication in a forthcoming issue of MACHINE DESIGN.

Fig. 4—Below—Much machining is eliminated on frame and cam of this switch through use of special-shape bars



As indicated above, not only was the cost of the part reduced considerably but it was also found "that the texture of the brass is more uniform and has better machining qualities than the casting".

This case serves to emphasize another advantage offered by special-shape bar, i.e., accurately oriented, smooth and uniformly shaped surfaces that are immediately available on the cut off blanks for positioning in jigs and fixtures used to facilitate drilling, reaming, tapping, slotting, etc. This is also a desirable feature when the shaped bar is to be worked in a screw machine wherein it often pays to install special chucks to handle specific shapes.

A part that is somewhat of a "natural" for production from special-shape bar is the contact base, detail of which is shown in *Fig.* 2. Some of these parts are shown in place on a locomotive controller in *Fig.* 3. The Goodman Manufacturing Company which produces this equipment reports a saving of 14 cents per piece on this item as compared to production from cast brass. Had this part been made from rectangular bar stock, an inordinate amount of machining would have been required to achieve the desired shape and, as one producer of special-shape nonferrous bar puts it, "who pays for the chips?"

Reappraisal of Existing Parts Needed

As the reader will note, the case histories that have been selected to point up the advantages offered by special-shape bar in this article deal with parts formerly made by some other process. This serves to indicate the value of not only carefully considering the use of extruded and drawn shapes for the parts of new machines but of reappraising the methods and materials used in making parts for machines now in manufacture°.

Approximately $8,000 per year in savings is indicated by the Kellogg Switch & Supply Company through the use of extruded and drawn brass shapes as compared to former methods in the production of various parts for the multipole, double-throw key switch shown in *Fig.* 4. The frame of this switch requires only cutting off, slotting, and drilling ten holes, four of which are tapped. As for the cam, after cutting off it is milled, drilled and tapped.

Practically all of the commercial grades of ferrous and nonferrous metals can be formed into bars of a veritably endless variety of cross-sectional shapes. Sometimes, in the case of steels, the bar is hot rolled instead of extruded before cold drawing. It would be extremely difficult for anyone to lay down any definite rules circumscribing the types or complexity of shapes possible to produce inasmuch as few reasonable shapes cannot be made if material having good workability is used in conjunction with proper process tooling. Some idea of the wide variety of shapes that can be made and that might be used for machine parts will be gleaned from the end views of *Fig.* 5.

Along with the various steels and high-copper alloys, aluminum and magnesium are also finding increased application in the form of special-shape bar for machine parts. Prior to the war, extruded magnesium bars were used to advantage in the manufacture of traverse bars in textile machines, knife bars in bread slicing machines and packaging machines, typewriter rolls and platens, etc. In addition, as structural shapes, extruded aluminum and magnesium alloys have seen extended usage, not only on aircraft but

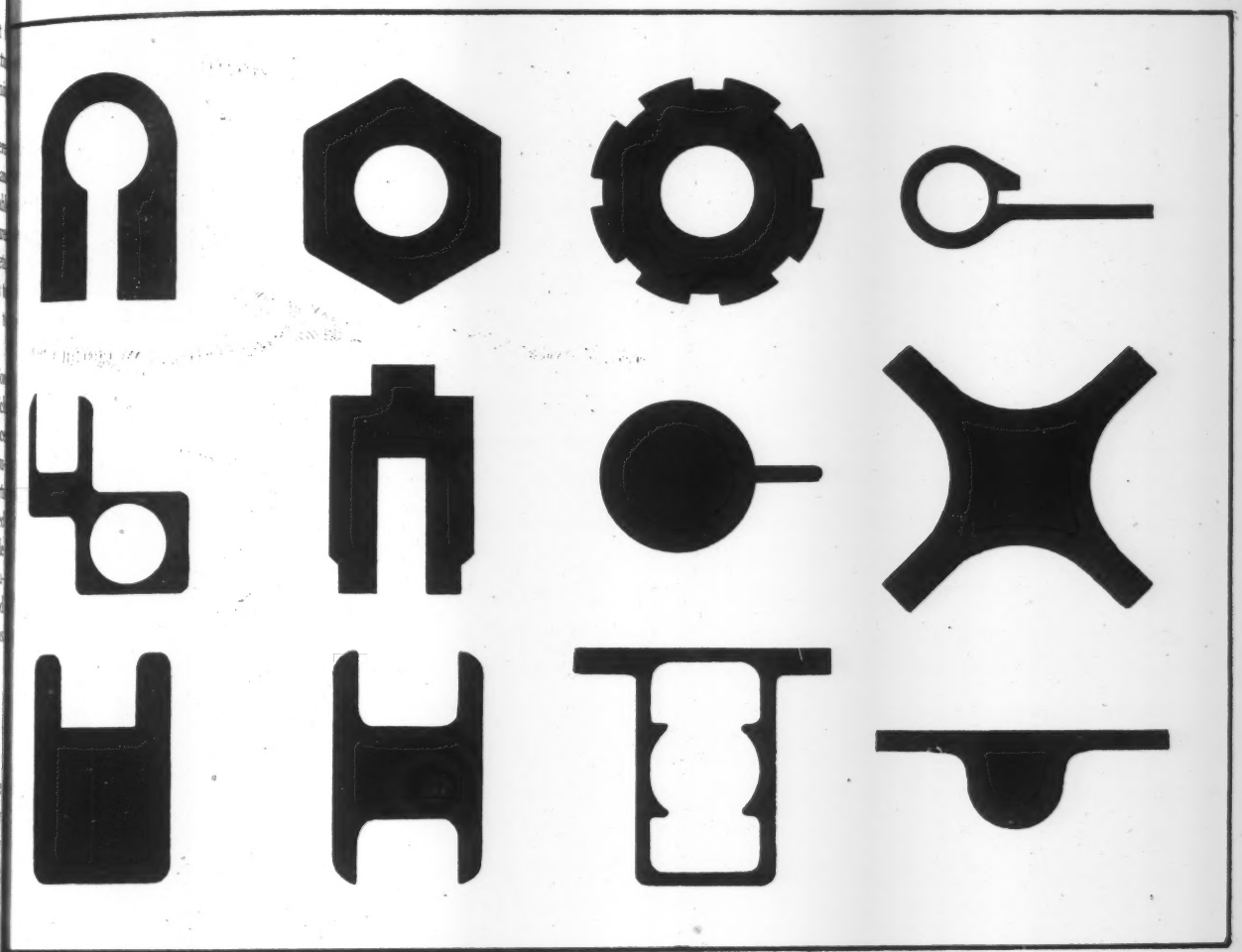
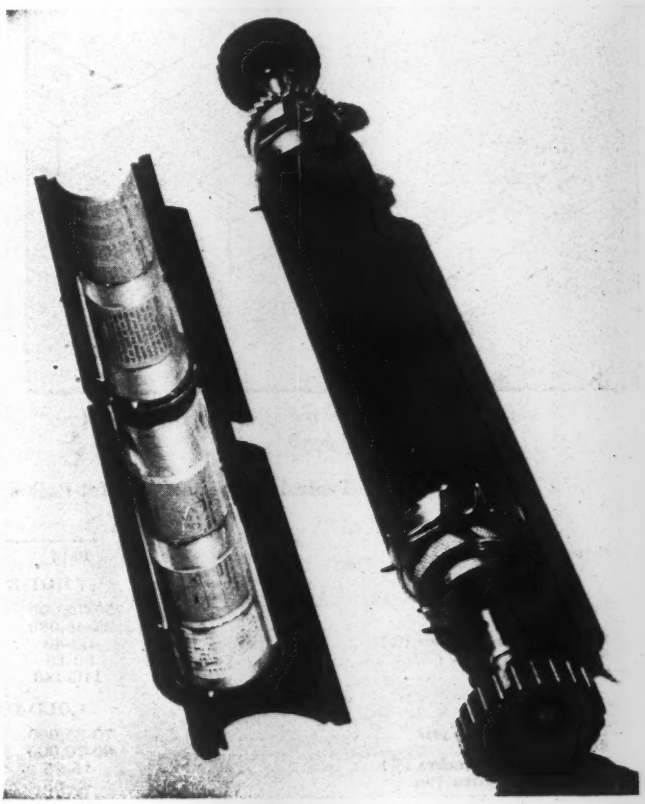


Fig. 5—Above—Shapes shown are representative of the wide variety that can be made by means of extrusion and cold drawing for the production of machine parts

Fig. 6—Below—Typewriter rolls made from extruded magnesium. Many parts are produced from extruded magnesium, both operational and structural



many other types of portable equipment as well. Typewriter rolls made from extruded magnesium are shown in Fig. 6.

A rather clever utilization of extruded and drawn bronze is exemplified by the part pictured in *Fig.* 7. This is the brake extension lever bushing used on the 1934 model automobile. After cut-off from the shaped bar, the part is press formed into the final semicircular shape shown. There is little question but that numerous other machine parts might be produced at worthwhile cost savings by adoption or an adaptation of this procedure.

Extruded Bar Ideal for Fittings

Many fine examples of parts made from extruded special-shape bar stock are found in the extensive line of fittings made by the Weatherhead Company of Cleveland. Representative of these are the parts shown in *Figs.* 8 and 9. This company reports that an overwhelming majority of its fittings are made from extruded bar, making possible a high-quality product at low cost.

All three of the fittings shown in *Fig.* 8 are used in the hydraulic brake systems of modern automobiles. In each of these pictures the extruded bar is shown, followed by the blank cut from the bar and, finally, the finished part. These drawings serve to emphasize an important feature of ex-

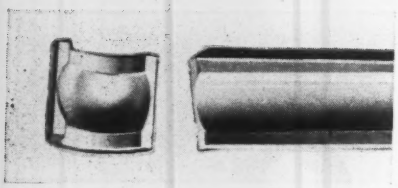
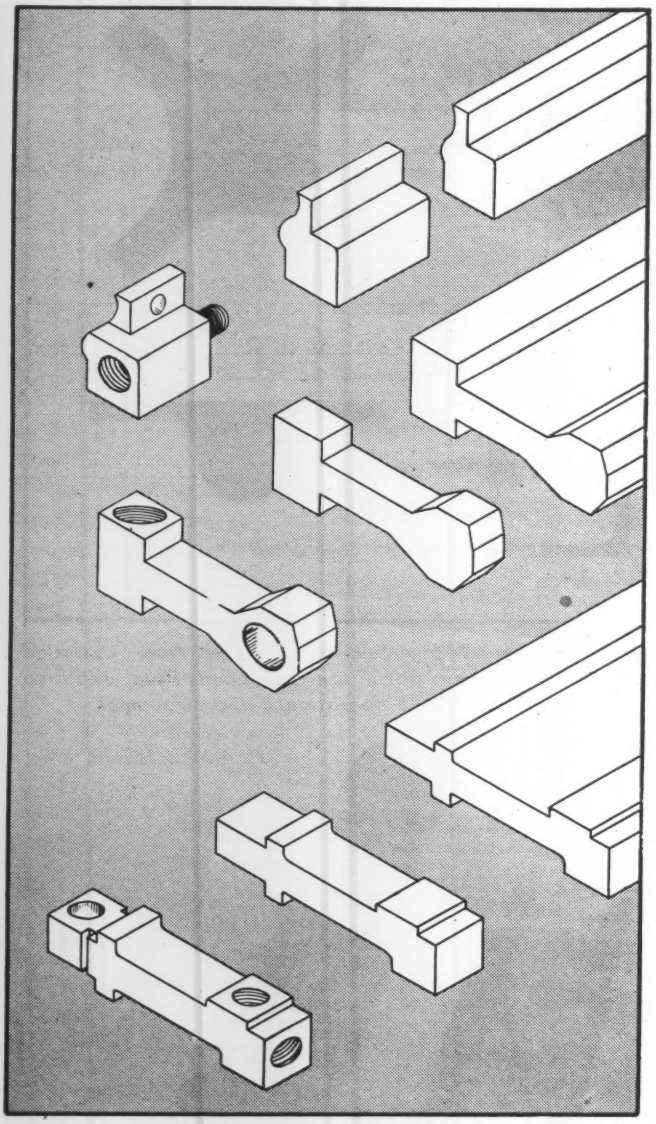


Fig. 7 — Left — Clever utilization of special-shape bar involves press-forming of blank after cutoff to semi-circular shape

Fig. 8—Below—Blanks are cut from special-shape bar and machined into finished parts. All three parts shown are fittings used in automobile hydraulic brake systems



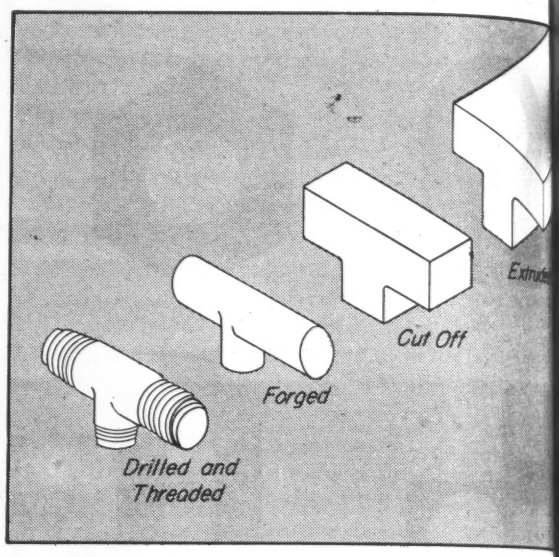


Fig. 9—Above—Steps in the production of a forged p from a blank cut from special-shape bar

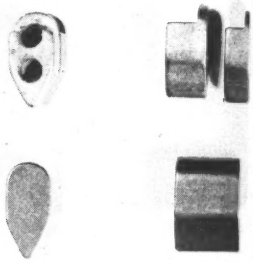


Fig. 10 — Right — Use of special-shape bar for these counter pinion liners saved milling costs

truded bar mentioned earlier in this article, namely, smoo and even locating surfaces to be used by the shop wh jigging or chucking the blanks for machining.

Forging manufacturers frequently find it desirable use forging stock in the form of blanks cut from speci shape extruded bar. By employing blanks having a proximately the shape of the finished forging, one or mo blocking operations often can be eliminated with cons quent cost reductions. An application where this proced proved advantageous is the Tee fitting shown in Fig As indicated in the drawing, first the blank is cut from th bar, next it is forged into the round-sectioned piece show and finally it is drilled and threaded. It might be well add at this point that the fine homogeneous structure

(*Concluded on Page* 152)

Typical Properties of Hot-Rolled and Cold-Drawn Carbon Steels

Properties	SAE GRADE OF STEEL 1015	1016	1035	1045	1050
HOT-ROLLED					
Tensile Strength (psi)	50-70,000	60-80,000	70-90,000	80-100,000	90-110,000
Yield Point (psi)	25-45,000	30-50,000	30-50,000	35- 55,000	45- 65,000
Elongation in 2 Inches (%)	30-40	30-40	20-30	20-30	15-25
Reduction of Area (%)	50-65	50-65	35-50	30-45	20-32
Brinell Hardness	110-140	137-170	143-182	156-202	179-223
COLD-DRAWN					
Tensile Strength (psi)	70-85,000	75-90,000	90-110,000	85-115,000	100-120,000
Yield Point (psi)	60-70,000	65-75,000	75- 90,000	80-100,000	85-100,000
Elongation in 2 Inches (%)	15-25	15-25	10-20	10-15	10-15
Reduction of Area (%)	45-55	50-55	40-55	30-45	30-45
Brinell Hardness	149-170	170-187	170-202	183-228	202-235

MACHINE *Editorial* DESIGN

New Era Beckons

WHILE political and military leaders ponder the impact of the atomic bomb on the balance of power between nations and the thought that another world war might mean the end of civilization, engineers rightly are keeping in mind the possibilities of harnessing this new elemental force for the benefit of mankind.

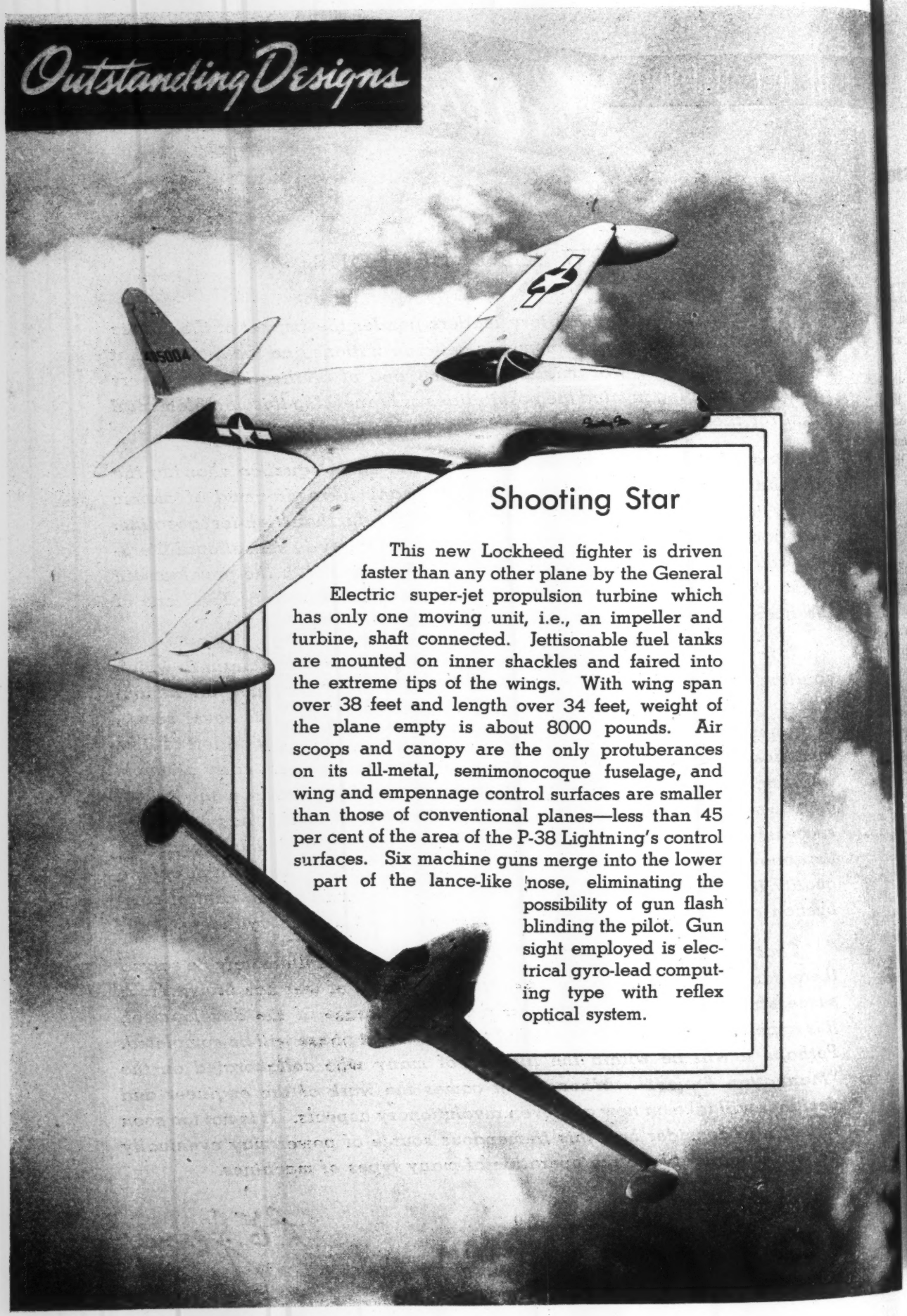
Since Einstein, forty years ago, wrote the basic equation showing the interchangeability of matter and energy, many have dreamed of atomic motors utilizing fuels two billion times more powerful than high-test gasoline. That goal, until recently thought to be attainable only in sensational literature and comic strips, is brought measurably closer with the development of the atomic bomb—said to be as powerful as 20,000 tons of TNT, one of the basic high explosives utilizing molecular energy.

It is one thing, however, to unleash the atomic reaction chain in which splitting atoms bombard and smash other atoms to produce an instantaneous blast of destruction "the like of which the world has never seen", and another to curb it so as to spread the effect over a long period of time and thus develop controlled power. It may be recalled that early attempts were made to develop internal combustion engines based on the use of gunpowder. Actually, no "explosive" material such as this has ever been successfully harnessed for the production of power, and it is significant that one of the major efforts of the war was the production of high octane quality in aviation gasolines, the sole purpose of which is to control combustion and prevent destructive explosions in the engine cylinders.

That the problems of controlling atomic energy will ultimately be solved there can be no doubt. While the terrific pressure of war has brought to a successful conclusion a particularly effective phase of the development, it is impossible for anyone to predict when the next phase will be completed. Perhaps it will be within the lifetime of many who collaborated on the "Manhattan Project". Whenever it comes the work of the engineer and designer will take on new and even revolutionary aspects. It is not too soon to begin to consider how this tremendous source of power may eventually be made applicable to the operation of many types of machines.

L. E. Jermy

Outstanding Designs

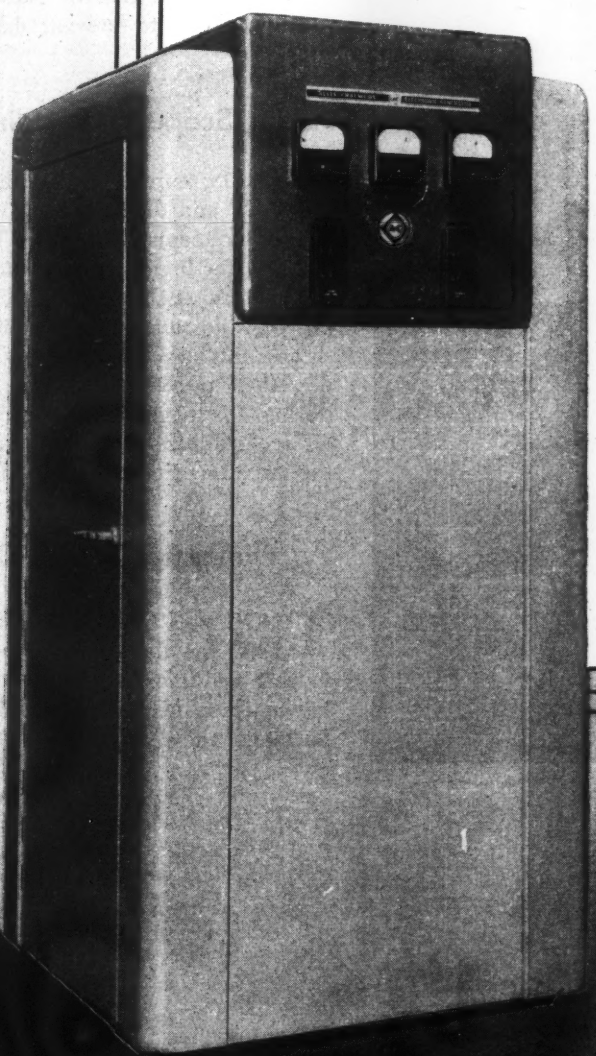


Shooting Star

This new Lockheed fighter is driven faster than any other plane by the General Electric super-jet propulsion turbine which has only one moving unit, i.e., an impeller and turbine, shaft connected. Jettisonable fuel tanks are mounted on inner shackles and faired into the extreme tips of the wings. With wing span over 38 feet and length over 34 feet, weight of the plane empty is about 8000 pounds. Air scoops and canopy are the only protuberances on its all-metal, semimonocoque fuselage, and wing and empennage control surfaces are smaller than those of conventional planes—less than 45 per cent of the area of the P-38 Lightning's control surfaces. Six machine guns merge into the lower part of the lance-like nose, eliminating the possibility of gun flash blinding the pilot. Gun sight employed is electrical gyro-lead computing type with reflex optical system.

Electronic Induction Heater

Simplicity and compactness are emphasized in the design of this new electronic induction heater developed by Allis-Chalmers. Top half of the steel-enclosed cabinet contains the oscillating circuit with two water-cooled oscillating tubes, oscillator tank coil, and choke coil. Below is the three-phase rectifying system with a heavy-duty transformer, a three-phase full-wave rectifier having six mercury-vapor tubes, and an industrial filament transformer for each tube.

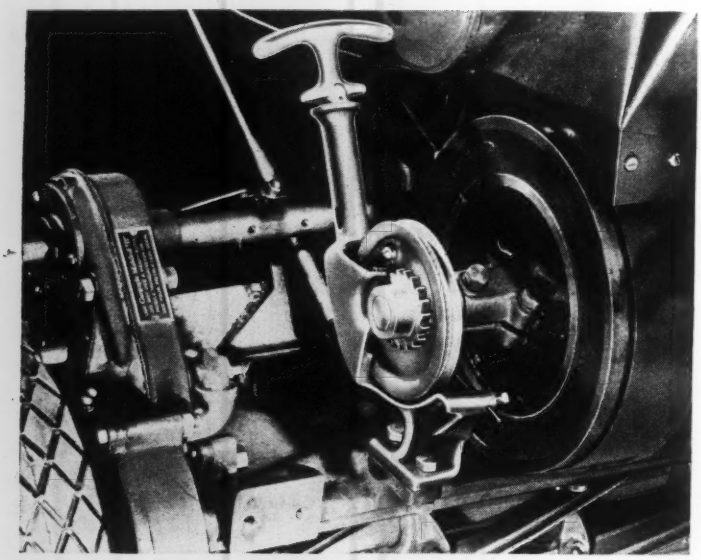


Cabinet construction is of supporting angle frame to which heavy gage cold-rolled steel plates are fastened by L clips. Of welded construction, this skeleton frame is horizontally braced and provides intermediate supports for the component electrical parts. Work buses which carry high frequency current to the work table are brought through an insulated panel at right side.

(New machines listed on Page 190)

Applications

of Engineering Parts, Materials and Process

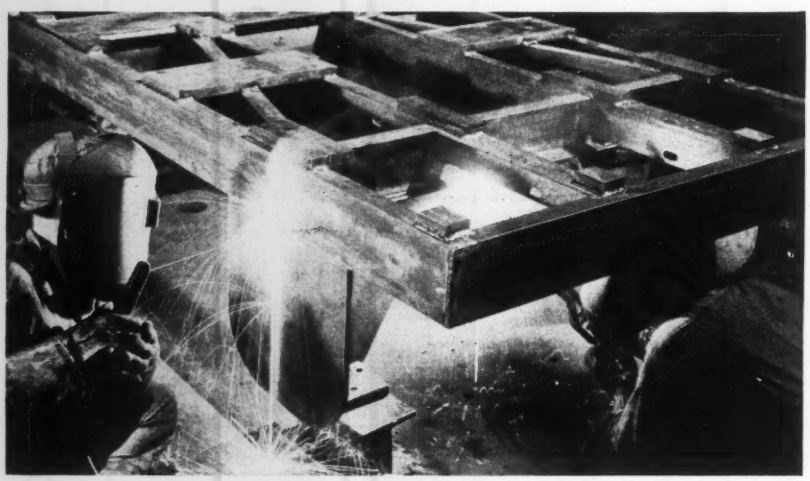


Automatic Recoil Starter

SAFETY against backfiring is provided by this uniq automatic recoil starter used on the Jacobsen cycle engine, left. The starter utilizes a ratchet a pulley attached to an extension of the crankshaft. the cable on the pulley is pulled, a pawl engages t ratchet to turn the engine. Disengagement of t ratchet is effected at the end of the stroke by a c on the starter bracket. In case of backfire the c acts in the same manner to prevent damage to t mechanism.

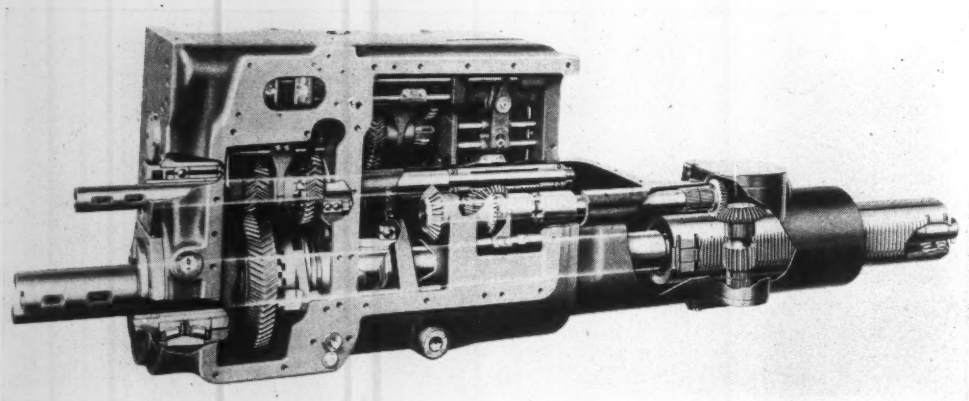
Widens Scope of Welding

A NEW alternating current arc welding electro known as ACP and developed by Westinghou meets the rigid requirements of the U. S. Navy Bure of Ships for high quality vertical and ov Lead welds as shown at left center. Ma ing possible satisfactory welding in all p sitions, this new electrode has an arc pac fier that prevents excessive spatter lo during the negative half cycles and al an arc stabilizer to aid in re-establishi the arc after each current zero.



Eliminates Wear, Galling

TOOL steel tubing, SAE 52100 type, used for the spindle sleeve bushi in this Giddings & Lewis horizontal b ing machine headstock. Replacing bron bushings, these thin-wall hardened slee fitted to a sliding Nitrall spindle maintain over unusually long period t built-in accuracy nec sary with this type m chine. Eliminating t wear, galling and scori encountered with pre ous designs, takeup mec anisms required with t original bronze bearing were obviated, great simplifying manufacturi problems.



Charts Facilitate Shaft Design

By Colin Carmichael
Associate Editor, Machine Design

ESTABLISHED procedures for shaft design may readily be followed with the aid of the accompanying charts. Elimination of the tedious operations involved in solving formulas facilitates testing variety of assumptions and design conditions, arriving at the most satisfactory and economical design.

In the following are outlined the principal calculations for which the charts are developed:

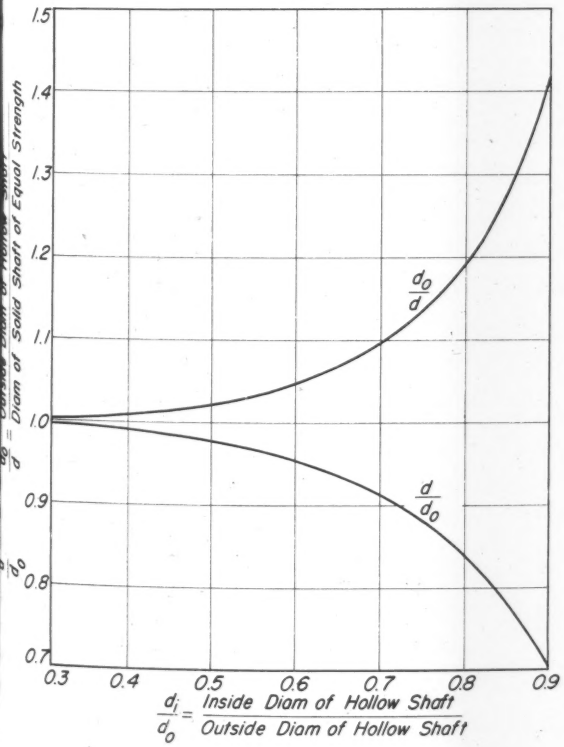
PURE TWISTING MOMENT: Shearing stress in a shaft subject to twisting moment only is given by the formula

$$S_s = \frac{16T}{\pi d^3} \quad \ldots\ldots (1)$$

where S_s = Maximum shearing stress, psi
T = Twisting moment, lb-in.
d = Shaft diameter (solid), in.

On the appropriate chart, *Figs.* 3, 4 or 5, a vertical through $T_1 = T$ is followed to the line corresponding to diameter d. Stress is read on right-hand scale.

Fig. 1—Relations between dimensions of solid and hollow shafts of equivalent strength



COMBINED LOADING, MAXIMUM SHEAR STRESS THEORY: Design of a shaft subject to combined twisting and bending moments, according to the maximum shear stress theory (ASME code), is based on the formula

$$d = \sqrt[3]{\frac{16}{\pi S_s}\sqrt{T_1^2 + M_1^2}} \quad \ldots\ldots (2)$$

where d = Shaft diameter (solid), in.
$T_1 = K_t T$
$M_1 = K_m M$
T = Applied twisting moment, lb-in.
M = Applied bending moment, lb-in.
K_t and K_m = Shock and fatigue factors (see table)

S_s = Maximum shearing stress, psi. Code recommends that working stress, S_s, be 30 per cent of the elastic limit in tension but not more than 18 per cent of the ultimate tensile strength.

Procedure for using the charts to solve Equation 2 is explained on Page 150 under "How to Use the Charts".

Shock and Fatigue Factors for Shaft Design

Load Application	K_t	K_m
Stationary shaft		
Gradual	1.0	1.0
Sudden	1.5-2.0	1.5-2.0
Rotating shaft		
Gradual or steady	1.0	1.5
Sudden, minor shocks	1.0-1.5	1.5-2.0
Sudden, heavy shocks	1.5-3.0	2.0-3.0

HOLLOW SHAFTS: Relations between the diameters of solid and hollow shafts of equal strength are as follows

$$d^3 = \frac{d_o^4 - d_i^4}{d_o} \quad \ldots\ldots (3)$$

$$\frac{d}{d_o} = \sqrt[3]{1 - \left(\frac{d_i}{d_o}\right)^4} \quad \ldots\ldots (4)$$

where d = Diameter of solid shaft
d_o = Outside diameter of hollow shaft
d_i = Inside diameter of hollow shaft.

Having found the proper diameter d of solid shaft

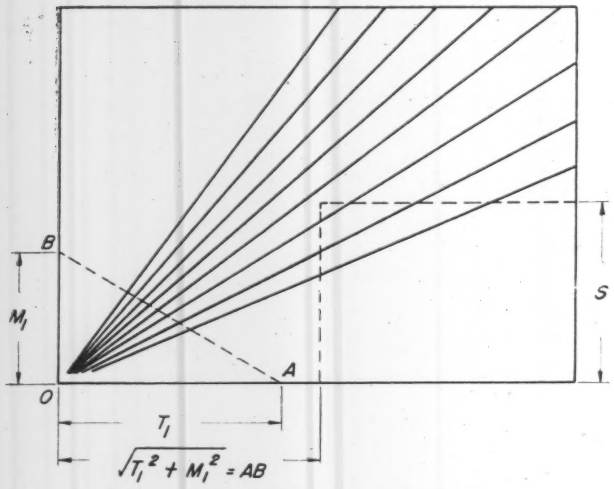


Fig. 2—Key to the use of Figs. 3, 4 and 5

through the use of *Fig.* 3, 4 or 5, dimensions of the equivalent hollow shaft may be found from Equations 3 or 4 or with the aid of *Fig.* 1. It will be observed that a hole less than one-third the outside diameter detracts but little from the strength.

COMBINED LOADING, DISTORTION-ENERGY THEORY: Design of a shaft subject to combined twisting and bending moments, according to the distortion-energy theory (see MACHINE DESIGN, Sept., 1942, Page 79, and Oct., 1942, Page 78), is based on the formula

$$d = \sqrt[3]{\frac{16}{\pi S_t}\sqrt{(1.73K_tT)^2 + (2K_mM)^2}} \quad \text{.....(5)}$$

where S_t is the working stress in tension. Other terms in the equation have the same values as before, but in using the charts it is important to note that the values of T_1 and M_1 are now as follows:

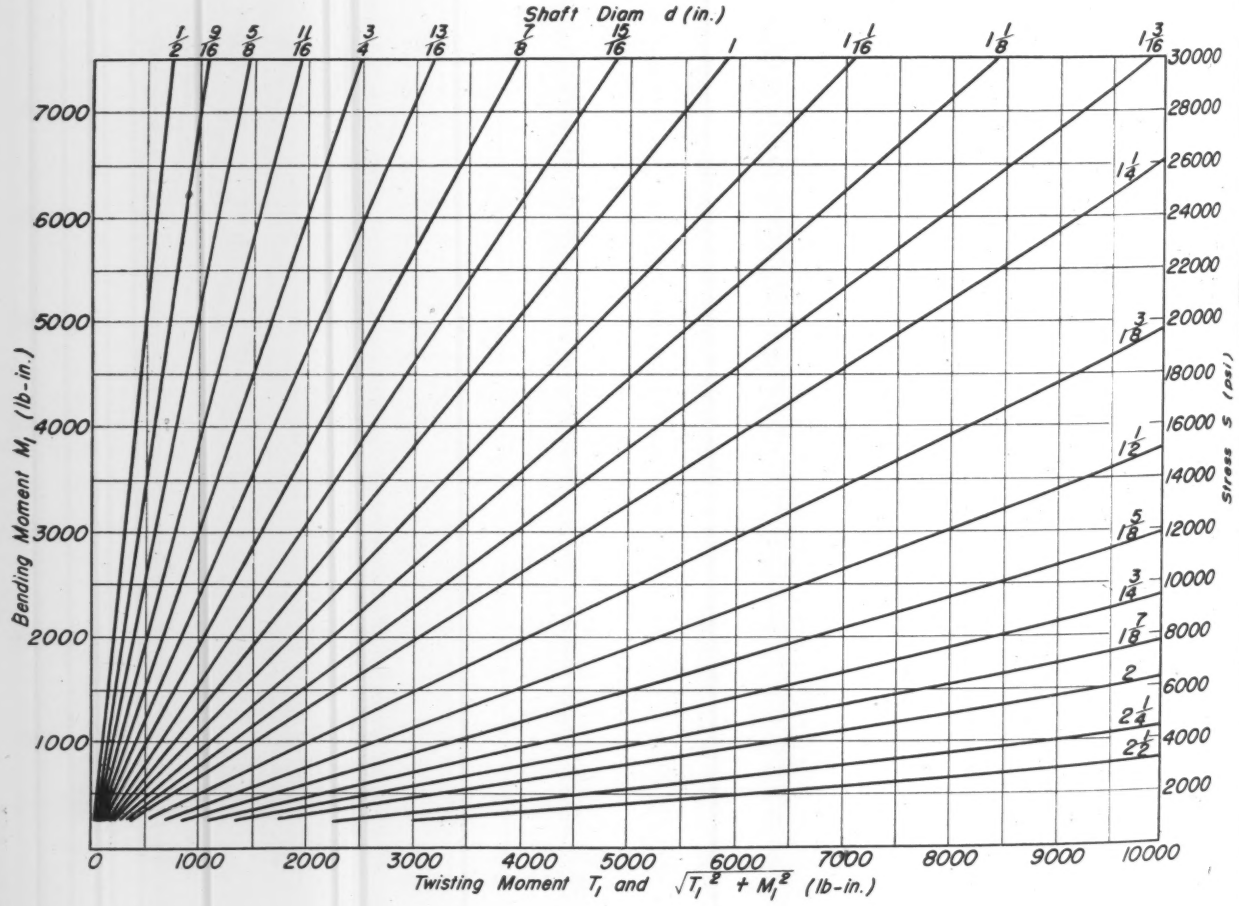
$$T_1 = 1.73K_tT$$
$$M_1 = 2K_mM$$

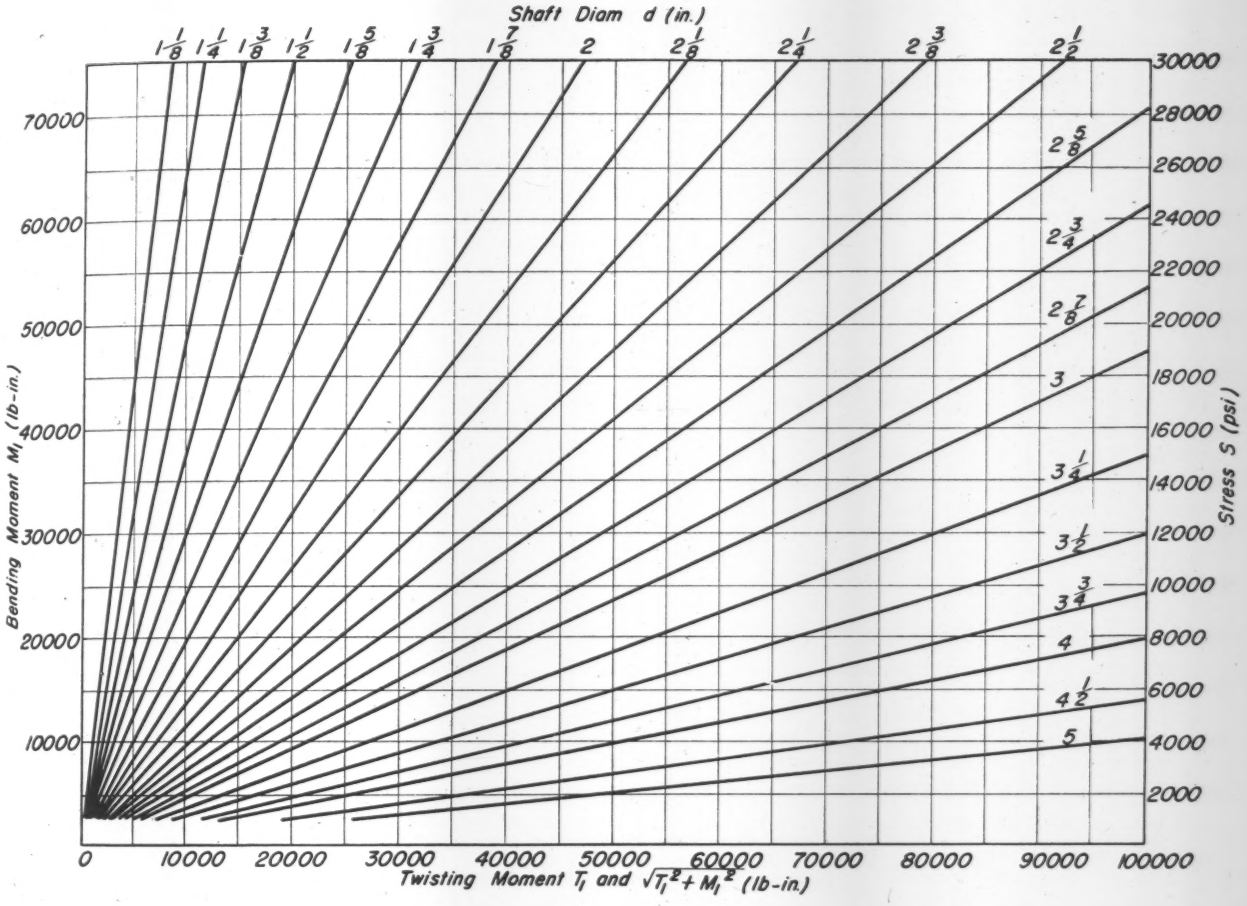
How To Use The Charts

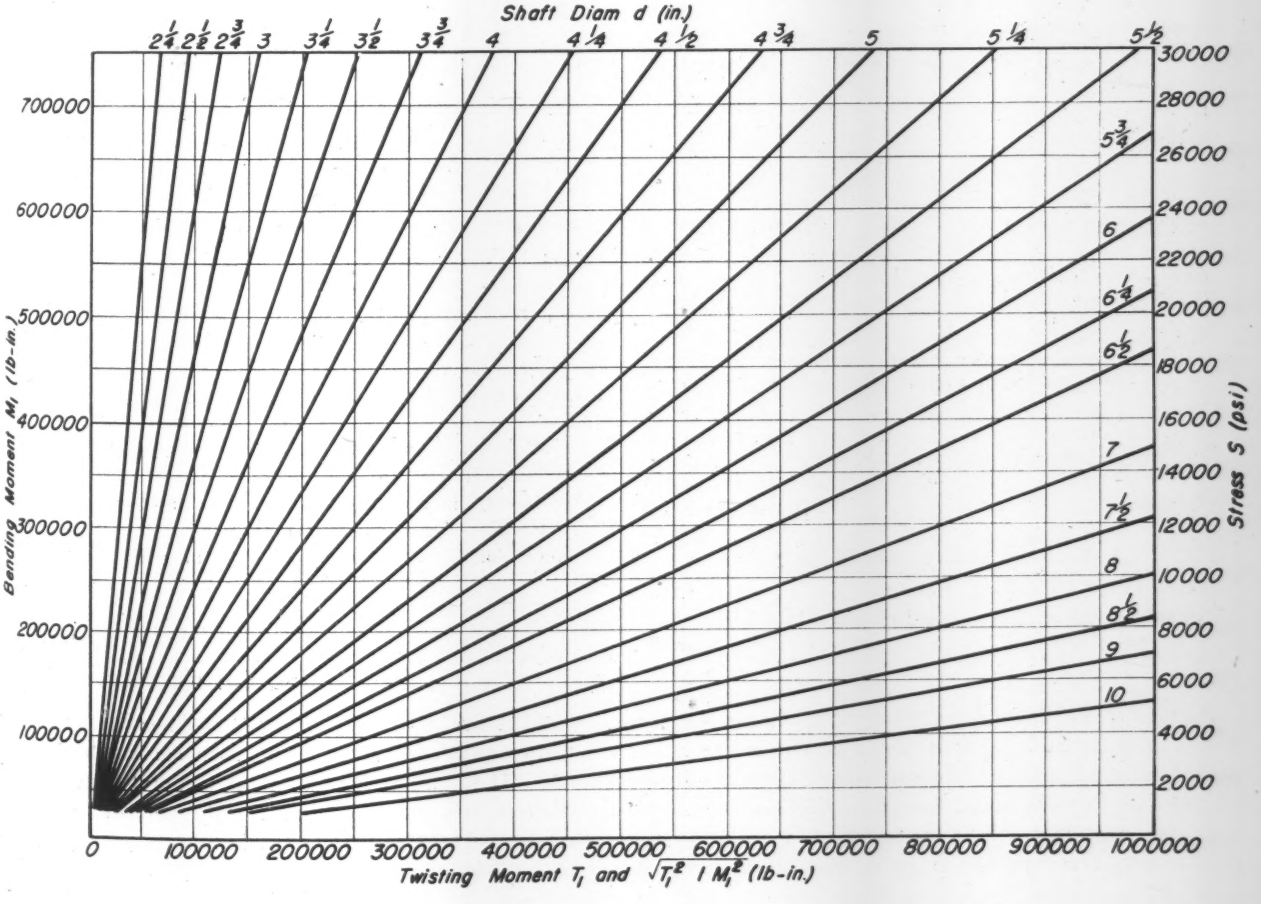
Referring to the key diagram at left, the general procedure is as follows:

1. Locate point A ($OA = T_1$) on base line scale
2. Locate point B ($OB = M_1$) on left-hand vertical scale
3. Measure distance AB and lay off on base line
4. Locate the intersection of a vertical through the point just found and a horizontal through the S value on the right-hand scale
5. Select diameter d from one of the adjacent lines on the chart.

Figs. 3, 4 and 5—Below and Opposite Page—Charts for solving shaft design problems




Shaft Diam d (in.)
1 1/8
1 1/4
1 3/8
1 1/2
1 5/8
1 3/4
1 7/8
2
2 1/8
2 1/4
2 3/8
2 1/2
2 5/8
2 3/4
2 7/8
3
3 1/4
3 1/2
3 3/4
4
4 1/2
5
Bending Moment M_i (lb-in.)
70000
60000
50000
40000
30000
20000
10000
Stress S (psi)
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
Twisting Moment T_i and $\sqrt{T_i^2 + M_i^2}$ (lb-in.)


Shaft Diam d (in.)
2 1/4
2 1/2
2 3/4
3
3 1/4
3 1/2
3 3/4
4
4 1/4
4 1/2
4 3/4
5
5 1/4
5 1/2
5 3/4
6
6 1/4
6 1/2
7
7 1/2
8
8 1/2
9
10
Bending Moment M_i (lb-in.)
700000
600000
500000
400000
300000
200000
100000
Stress S (psi)
30000
28000
26000
24000
22000
20000
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
100000
200000
300000
400000
500000
600000
700000
800000
900000
1000000
Twisting Moment T_i and $\sqrt{T_i^2 + M_i^2}$ (lb-in.)

Special-Shape Bar

(*Concluded from Page* 144)

extruded metal insures pressure tightness to these fittings and also results in a bare minimum of scrap due to defective parts.

Some very interesting cost comparisons are reported by the National Cash Register Company regarding the use of low-carbon cold-drawn steel shapes in the production of parts for accounting machines. Both the counter pinion liners, *Fig.* 10, and the impression selecting pawl of *Fig.* 11 formerly were machined from regular rectangular bar stock. It is worthy of note that savings effected annually on these two items alone, as indicated in the following tabulation, amount to approximately $2,230. Note too, in the case of the pawls, that while the cost of the material was greater for the special-shape bar, this slight additional

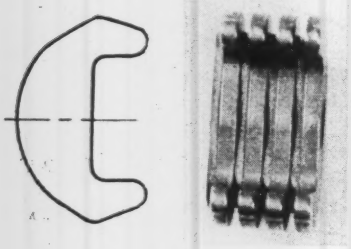


Fig. 11—Left—Reduction of milling on 24,000 of these pawls through use of special-shape bar saves producer approximately $500

cost was offset more than 3½ times by the saving effected in labor cost.

Impression Selecting Pawls
Produced From Regular Rectangular Bar

Material Cost	$ .2468 per 100 pieces
Labor Cost	$3.174 per 100 pieces
Total	$3.4208 per 100 pieces

As Produced From Special-Shape Bar

Material Cost	$ .993 per 100 pieces
Labor Cost	$ .354 per 100 pieces
Total	$1.347 per 100 pieces
Amount saved, based on annual usage of 24,000 pieces	Approximately $500

Counter Pinion Liners
Produced From Regular Rectangular Bar

Labor Cost (for milling a .125-in. radius on the bottom end)	$1.59 per 100 pieces
Labor Cost (for milling a 25-deg, 30-min. 32-sec angle on opposite end)	$1.87 per 100 pieces
Total	$3.46 per 100 pieces

As Produced From Special-Shape Bar

Labor Cost (for milling as above)	None
Amount saved on labor, based on annual usage of 50,000 pieces	$1,730

Applications of special-shape bar veritably run the gamut of the machine building industry. Pictured in *Fig.* 12 is a pocket transit the cover hinge of which is produced from extruded and drawn brass. According to Wm. Ainsworth & Sons Inc., manufacturers of the transit, ". . . .to obtain the rigidity and accuracy necessary in the special hinge it is impossible to use a punched and formed construction [illegible] to mill the piece from rectangular bar would involv[illegible] cost of at least double that of the extruded design."

Dimensional tolerances that can be held on spec[illegible] shape bars vary with size, material and forming meth[illegible] While bars of small cross-sectional area can be held as c[illegible] as one thousandth, really large sections may requir[illegible] latitude of over fifty thousandths. Bar that is drawn a[illegible] extruding generally can be held to closer tolerances t[illegible] bar that is extruded only. If it is determined that consi[illegible] able machining can be eliminated by using special-sh[illegible] bar, the most practical procedure is to draw up the [illegible]

Fig. 12—Hinge of this pocket transit is produced fr[illegible] extruded and drawn brass as shown in insert

tion required with tolerances fully specified and consul[illegible] reliable producer.

Looking toward the future and additional possibilities [illegible] the application of special-shape bar, it would seem adv[illegible] able to explore more fully the feasibility of building up m[illegible] chine parts of sections cut from these shapes. Stampin[illegible] formings, and screw machine parts have often been c[illegible] bined advantageously in this manner using brazing, s[illegible] welding, staking, etc., for the fastening means. It appe[illegible] likely that use of parts produced from special-shape b[illegible] might help to widen this field of application considerab[illegible]

MACHINE DESIGN is pleased to acknowledge the gener[illegible] collaboration of the following companies in addition to th[illegible] mentioned in the article: A. B. & J. Rathbone; The Americ[illegible] Brass Co.; The Dow Chemical Co. (*Fig.* 6); Jones & Laugh[illegible] Steel Corp.; Republic Steel Corp.; and Reynolds Metals C[illegible]

Jet Engine Lubrication

AIRCRAFT GAS-TURBINE engines for jet-propuls[illegible] planes require heating rather than cooling for lubricati[illegible] oil. The reason, according to General Electric, is th[illegible] there is only one moving part in the unit and, because th[illegible] rotates without appreciable vibration, it can be support[illegible] on antifriction bearings.

MACHINE DESIGN'S

MATERIALS WORK SHEET

FILING NUMBER
7.00

Carbon Cast Steels

ASTM SPEC. NOS.: A27-44, A87-44, A215-44, A216-44T

Specifications of the American Society for Testing Materials (ASTM) for Carbon Cast Steels fix only the *minimum* mechanical properties. Properties higher than those listed can be obtained by varying the chemical compositions and by subjecting cast parts to various heat treatments.

It is suggested that the designer select the steel to be used from the standard (ASTM) specifications and, after acquainting the foundry with any additional properties required in a given part, leave the compounding of the steel and recommendations for its heat treatment in the hands of a competent foundryman.

PROPERTIES PRESCRIBED IN ASTM SPECIFICATIONS

ASTM Specification No.	Class	Heat Treatment*	Tensile Strength (min, psi)	Yield Strength (min, psi)	Elong. in 2 Inches (min, %)	Red. of Area (min, %)
Carbon-Steel Castings for Miscellaneous Industrial Uses						
A27-44	A1	U	60,000	30,000	22	30
A27-44	A2	N or A	60,000	30,000	26	38
A27-44	A3	A	60,000	30,000	24	35
A27-44	B	N or A	70,000	38,000	24	36
A27-44	B1	A	66,000	33,000	22	33
A27-44	B2	A	70,000	35,000	20	30
A27-44	H	N or A	80,000	43,000	17	25
A27-44	H1	A	80,000	40,000	17	25
Carbon-Steel Castings for Railroads						
A87-44	A1	U	60,000	30,000	22	30
A87-44	A2	N or A	60,000	30,000	26	38
A87-44	B	N or A	70,000	38,000	24	36
Carbon-Steel Castings Suitable for Fusion Welding for Varied Industrial Uses						
A215-44	A1W	U	60,000	30,000	22	30
A215-44	A2W	A or N	60,000	30,000	26	38
A215-44	A3W	A	60,000	30,000	24	35
A215-44	BW	A or N	70,000	38,000	24	36
A215-44	B1W	A	66,000	33,000	22	33
A215-44	B2W	A	70,000	35,000	20	30
Carbon-Steel Castings Suitable for Fusion Welding for Service at Temperatures up to 850 Degrees Fahr.						
A216-44T	WCA	A or N.T.	60,000	30,000	24	35
A216-44T	WCB	A or N.T.	70,000	36,000	22	35

* U—Unannealed, N—Normalized, A—Full Annealed, N.T.—Normalized and Tempered.

MACHINE DESIGN is pleased to acknowledge the collaboration of the Steel Founders' Society of America in this presentation. Data included are abstracted from the Society's *Steel Castings Handbook*.

CHARACTERISTICS

LOW-CARBON STEELS:

Comprise an extremely small percentage of steel castings output. Properties of these steels in both normalized and fully annealed conditions are substantially the same. While their "as cast" and annealed properties are also about the same, annealing relieves the castings of internal stresses and improves their impact strength. Where design is based on endurance strength, it is safe to estimate the endurance limit at 40 per cent of the tensile strength, applying, of course, a suitable factor of safety. In the fully annealed state, the tensile strength of these steels reaches a maximum at temperatures between 400 to 600 degrees Fahr., while elongation and reduction of area are at their lowest values in this temperature range. In general impact strength decreases as carbon content increases. Values that normally can be expected of steels (fully annealed) in this group having various carbon contents are:

Carbon Content (%)	Tensile Strength (psi)	Yield Strength (psi)	Elong. in 2 inches (%)	Red of Area (%)
0.13 ...	60,000	33,500	34	59
0.15 ...	62,000	34,000	33	57
0.18 ...	65,000	36,000	32	54
0.20 ...	67,000	38,000	31	52

Indicative of the properties offered by low-carbon steels at elevated temperatures are the test values listed in the table "Test Properties of Low-Carbon Cast Steel at Elevated Temperatures".

MEDIUM-CARBON STEELS:

These grades comprise about two-thirds of all steel castings produced. Full annealing, normalizing, and normalizing plus tempering have pronounced effects in raising the strength, elongation and reduction of area of these steels. However, these heat treatments do not alter tensile strength a great deal although they are, of course, valuable in relieving internal stresses.

Impact resistance, which decreases as carbon content increases, is influenced greatly by heat treatment. Impact properties are lowest in these steels when "as cast", slightly higher when fully annealed, still higher when normalized with further improvement effected by tempering after normalizing. Best impact resistance is exhibited by these steels when they are hardened by quenching in water and tempered at from 1000 to 1300 degrees Fahr. Hardening and tempering, however, are possible only when the casting design is such as to permit liquid quenching. When design is based on endurance properties, it is safe to estimate the endurance limit as 40 per cent of the tensile strength. Values that normally can be expected of normalized steels in this group having various carbon contents are:

TEST PROPERTIES OF LOW-CARBON CAST STEELS AT ELEVATED TEMPERATURES

(all compositions heated to 1650 F for 5 hrs., furnace cooled)

Composition No.§	Mechanical Properties	Temperature of Test (deg Fahr) 70	212	390	570	750
1	Tensile Strength (psi)	51,000	47,000	61,000	61,000	41,000
	Elastic Limit (psi)	25,000	22,000	22,000	13,000	10,000
	Yield Point (psi)	26,000	24,000	22,000	16,000	15,000
	Elongation (%)	36.2	33.3	23.3	26.2	39.2
	Reduction of Area (%)	66.3	64.2	54.9	55.0	66.5
2	Tensile Strength (psi)	59,000	51,000	58,000	60,000	54,000
	Elastic Limit (psi)	33,000	26,000	26,000	14,000	15,000
	Yield Point (psi)	34,000	27,000	27,000	19,000	20,000
	Elongation (%)	18.6	19.8	10.5	13.5	21.6
	Reduction of Area (%)	28.7	35.6	22.8	21.0	26.5
3	Tensile Strength (psi)	64,000	62,000	75,000	75,000	61,000
	Elastic Limit (psi)	33,000	32,000	32,000	24,000	19,000
	Yield Point (psi)	35,000	33,000	32,000	26,000	23,000
	Elongation (%)	28.5	23.9	16.0	23.2	24.9
	Reduction of Area (%)	40.2	43.7	22.8	31.6	37.8
4	Tensile Strength (psi)	64,000	61,000	63,000	64,000	53,000
	Elastic Limit (psi)	38,000	35,000	33,000	19,000	16,000
	Yield Point (psi)	39,000	36,000	33,000	25,000	21,000
	Elongation (%)	29.6	29.5	22.1	21.6	30.8
	Reduction of Area (%)	51.2	51.3	44.0	43.2	49.5

§No. 1: C—0.12, Mn—0.32, Si—0.25, S—0.023, P—0.011.
No. 2: C—0.14, Mn—0.45, Si—0.29, S—0.037, P—0.016.
No. 3: C—0.17, Mn—0.67, Si—0.23, S—0.076, P—0.088.
No. 4: C—0.18, Mn—0.77, Si—0.19, S—0.043, P—0.064.

TEST PROPERTIES OF HIGH-CARBON ANNEALED CAST STEEL AT ELEVATED TEMPERATURES

(short-time tests, steel contains C-0.53, Mn-0.28, Si-0.22%

	Temperature of Test (deg Fahr) 70	212	390	570	750
Tensile Strength (psi)	81,000	75,000	71,000	75,000	71,000
Yield Strength (psi)	31,000	29,000	27,000	25,000	24,000
Elastic Limit (psi)	28,000	29,000	25,000	19,000	16,000
Elongation (%)	16.1	17.9	14.9	9.3	13.7
Reduction of Area (%)	15.9	19.1	18.3	12.2	14.8

bon tent)	Tensile Strength (psi)	Yield Strength (psi)	Elong. in 2 inches (%)	Red of Area (%)
22 ...	73,000	40,000	31	52
25 ...	76,000	43,000	29	49
30 ...	82,000	48,000	27	45
35 ...	87,000	52,000	25	40
40 ...	92,000	53,000	23	36
45 ...	97,000	55,000	21	32

H-CARBON STEELS:

hese comprise only a small percentage of the total l castings output. Mechanical properties normally to expected in the fully annealed condition with carbon ents ranging from 0.50 to 1.00 per cent are:

bon tent)	Tensile Strength (psi)	Yield Strength (psi)	Elong. in 2 inches (%)	Red of Area (%)
50 ...	96,000	53,000	17	25
60 ...	106,000	57,000	13	17
70 ...	113,000	60,000	9	11
80 ...	120,000	62,000	7	7
90 ...	125,000	64,000	5	5
00 ...	128,000	65,000	4	4

ome idea of the properties of high-carbon cast steels at ated temperatures may be gleaned from the table "Test perties of High-Carbon Annealed Cast Steel at Elevated mperatures" which lists results of short-time tests made n annealed steel containing percentages of 0.53 carbon, manganese and 0.22 silicon.

lthough, as will be noted from the table, elongation reduction of area show pronounced drop between 400 600 degrees Fahr., impact tests indicated no embrittle- t at these temperatures.

APPLICATIONS

OW-CARBON CAST STEELS: Used primarily for parts re- ring exceptionally high ductility or high magnetic perme- ity. Where parts need a hard, wear-resistant exterior s a tough, ductile core, these steels often are case burized.

MEDIUM-CARBON CAST STEELS: For parts requiring good nbinations of strength and ductility. Used in practically heavy machine industries such as railroad, trucking, chine tool, rolling mill equipment, etc., for machine mes and stressed housings, flywheels, bolsters, drums and m spiders, connecting rods, gears, levers and links, etc.

HIGH-CARBON CAST STEELS: Principally used in the metal- rking industry for bending, blanking and forming dies. rts such as rolls and various tools, requiring considerable rdness, resistance to wear and abrasion, and high rigidity, o are made from these steels.

FABRICATION

CHINABILITY:

n general the machinability of carbon cast steels is ilar to that of wrought steels of equivalent strength and tility, like indentation hardness and similar microstructure. To conserve cutting tool life it is recommended that first cuts be deep enough to remove the surface skin which often contains particles of grit and sand.

Plain carbon cast steel of from 0.25 to 0.35 per cent carbon, when properly heat treated has excellent machinability, both from the metal removal and finish standpoint. It is a little more difficult to obtain a satisfactory finish on the lower carbon class (0.20 per cent carbon) because of its high ductility. Steels of the 0.40 to 0.50 per cent carbon class take an excellent finish but tool life usually is lower than with the more machinable 0.25 to 0.35 per cent carbon grade. Steel in the "as cast" condition usually is considered more difficult to machine than after it has been properly heat treated. Best surface finish is produced on medium-carbon steel in the normalized condition and on high-carbon steel in the spheroidized condition.

WELDING:

The low-carbon cast steels are easily welded by all of the welding processes and the resultant welds and joints are of extremely high quality. Medium-carbon cast steels can be welded with the various fusion processes. In some cases preheating and subsequent heat treatment may be required to produce the desired weld quality, particularly for steels containing over 0.40 per cent carbon. High-carbon cast steels, because of their high carbon content, are more difficult to weld than the low or medium-carbon types. With proper techniques, however, they can be gas, arc, bronze, or thermit welded.

HEAT TREATMENTS

NORMALIZING AND FULL ANNEALING:

Normalizing and full annealing both are processes in which the metal is heated to about 100 degrees Fahr. above the critical temperature range followed by cooling. It is in the method of cooling that normalizing and full annealing differ. In normalizing, cooling is effected in still air at room temperature. In full annealing, cooling is done in a furnace and the rate of cooling is slower than in normalizing.

In general, normalizing produces higher yield and ultimate strength than full annealing. Ductility is approximately the same after either treatment, but normalizing often gives higher impact resistance. Full annealing gives a softer steel and greater freedom from stresses but ties up furnace equipment for longer periods of time.

TEMPERING AFTER NORMALIZING:

Castings may be tempered after normalizing (seldom after full annealing) to further remove stresses and to improve ductility and impact resistance, sometimes at a sacrifice of strength, depending on the tempering temperature employed. For removal of stresses, temperatures ranging between 500 and 1000 degrees Fahr. generally are used. Ordinarily temperatures below 1000 degrees Fahr. have no effect on strength or ductility in a normalized steel. Above 1000 and up to 1300 degrees Fahr. strength is progressively lowered and ductility is moderately improved.

QUENCHING AND TEMPERING:

Where the design of the casting is such as to permit liquid quenching, and when the carbon content of the material is above 0.30 per cent, heating followed by quenching in

water or oil can serve to bring out the greatest strength of the steel and, by hardening its surface, give it good wear resistance. Occasionally the casting is annealed or normalized before quenching to guard against cracking. Tempering is done immediately after quenching. Tempering decreases brittleness, improves toughness and relieves quenching stresses. However, it also decreases hardness and strength. Wherever possible heat treatment should be recommended by a competent foundryman and the treatment actually performed at the foundry. When castings must be heat treated after machining for the purpose of removing machining stresses, it is wise to consult the foundry for its recommendations.

RESISTANCE TO CORROSION†

Unprotected by metallic or nonmetallic coatings, carbon steels will rust in atmospheric and natural-water exposure. They are rapidly attacked by most acid solutions but show good resistance to alkalies. In the neutral range of aqueous solutions in the presence of air they have poor resistance, the surface film that develops being poorly protective at best.

There are, however, many corrosion-resistant finishes that can be applied to carbon cast steels. In addition to numerous paints and enamels, there are of course the metallic coatings such as zinc, tin, cadmium, lead, chromium, and nickel. Zinc generally is applied by the hot-dip galvanizing process.

GALVANIC CORROSION†

In galvanic behavior these steels act as anodic (corroded) metals to copper, nickel, bronzes, brasses, chromium, stainless steels (usually), platinum, and as cathodic (protected) metals to aluminum, zinc and cadmium. Tin and lead are close to iron in electrochemical character; tin may be cathodic or anodic depending on factors such as aeration, and lead usually is cathodic. Of course galvanic corrosion can exist only when the dissimilar metals are in contact in the presence of moisture. Protective coatings that serve to separate the two metals will effectively curtail such corrosion.

DESIGN TIPS

(Applying to all steel castings)

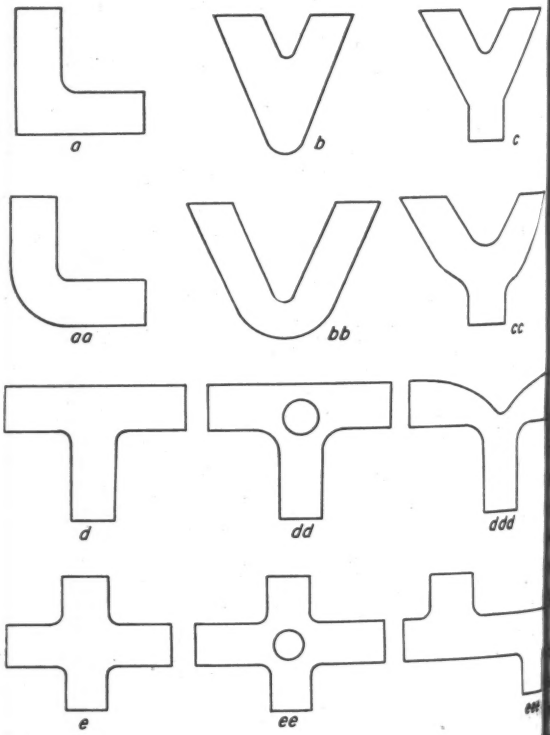
KEEP SECTIONS AS UNIFORM AS POSSIBLE: Care should be exercised to maintain all section thicknesses of a casting as uniform as is practicable. Where it becomes necessary to have adjoining sections of different thicknesses the change from one thickness to another should be as gradual as possible. This is necessary because thin sections solidify in the mold sooner than do thick sections and the resulting drawing action, due to unequal size-contraction during cooling, sets up stresses which seek out the weakest spot in the casting—generally the juncture between the contrasting sections—with the tendency for a crack or tear to develop.

†*Corrosion Resistance of Metals and Alloys*, 1936, Reinhold Publishing Corp.

SPECIFY PROPER FILLETS: In general, a good though infallible rule of thumb is to specify fillet radii equal to thickness of the adjoining sections. However, since sh corners or corners with insufficiently large fillet radii p duce stress concentration points, and fillets that are t large cause excessive shrinkage cavities, it often is best leave the radii of as many fillets as possible to the discre of the patternmaker. Of course radii that have a dir bearing on the functioning of the part must be specified the designer, but even in these cases, if there is any qu tion as to the effect of the fillet size on casting characteristi it is well to solicit the suggestions of a patternmaker.

CONSIDER CAST-WELD CONSTRUCTION: Often a steel c ing becomes extremely complex in design and its intric makes casting difficult or impractical. In such cases it wise to consider building up the complete unit from separ more easily cast parts which may be joined readily by we ing into a structure of good homogeneity having excell properties.

SEEK UNIFORM AREAS AT JOINTS: Five primary ways employed in joining cast sections. These are the L, V, and X types of joints. If the area of the section formed any of these joints is greater than that of an adjoining tion, a hot spot is apt to develop in the joint due to the ferent contraction rates during cooling, and these often rise to defects. Joint designs subject to the formation hot spots are shown in sketches *a, b, c, d,* and *e.* Those signed to obviate hot spots are shown in sketches *aa, cc, dd, ddd, ee,* and *eee.* It should be noted that the co hole type of joint design, *dd* and *ee,* has limited applicat being useful only where the intersection is not extensive intricate and involved.



ASSETS to a BOOKCASE

Principles of Firearms

By Charles E. Balleisen; published by John Wiley and Sons, Inc., New York; 140 *pages,* 5 *by* 8¼ *inches, clothbound; available through* MACHINE DESIGN, $2.50 *postpaid.*

For engineers engaged in the production of automatic ns or as a matter of fact anyone interested in firearms, s book presents a clear analytical approach to the de- n, manufacture and operation of small arms. Expound- g the theory that an automatic firearm is a piece of chinery operating in accordance with well known laws physics and capable of being analyzed and designed accordance with common engineering practice, the hor covers this subject from the viewpoint of the me- anical engineer and designer of machines.

Treating a limited number of familiar weapons the ter discusses gun barrels, recoil mechanisms, functions automatic weapons, operating systems, and five sample es of automatic guns. The remainder of the book devoted to trigger and sear mechanisms, cartridge ds, sights, unsolved problems in design, testing of apons, exterior ballistics, and gun mounts.

Profusely illustrated with drawings and charts, this thoritative volume contains sufficient introductory ma- ial to prove a valuable guide to the uninitiated student d the advanced data not readily available heretofore ll prove to be of great interest to the design engineer.

□ □ □

The Modern Gas Turbine

By R. Tom Sawyer; published by Prentice-Hall, Inc., New York; 216 *pages,* 6 *by* 9 *inches, clothbound; available through* MACHINE DESIGN, $4.00 *postpaid.*

This is an up-to-the-minute work dealing with the mod- n gas turbine and its various uses as a supercharger and me mover in all fields of service including jet propul- n. The author not only presents the reader with a clear rking knowledge of gas-turbine operation, but delves k into history to complete the picture with a chrono- gical outline of its development over the years.

Use of diesel exhaust for supercharging or operating a me mover is discussed, and all the known applications covered thoroughly. Recent improvements in gas- bine efficiencies are dealt with, as well as performance tors, mechanical aspects, general design and fuels. apters dealing with the use of the gas turbine in indus- , and locomotive and marine service bring together a large amount of useful information on present applications and future possibilities of these units. Interesting information is given regarding materials capable of withstanding the extreme temperatures and stress of turbine operation, especially in aircraft turbosuperchargers.

□ □ □

Manual on Design and Application of Helical and Spiral Springs for Ordnance

Published by the Society of Automotive Engineers Inc., New York; 89 *pages,* 8½ *by* 11 *inches, paperbound, available through* MACHINE DESIGN, $1.00 *postpaid to SAE members,* $2.00 *to nonmembers.*

Most designers of springs aim for maximum possible endurance life as the prime requisite for most ordinary spring applications. However, this is not the case in ordnance work where minimum weight and size, limited life expectancy, and absolute reliability must prevail.

For any designer of springs as well as those involved expressly in ordnance this manual furnishes a wealth of information on the characteristics of available spring materials, fabricating methods, and design features peculiar to ordnance springs. Limits are designated within which these materials and methods may be safely used. Data and recommendations represent the coordinated views of a great many leading fabricators and users of springs and spring materials.

□ □ □

ASTM Standards on Copper and Copper Alloys

Published by the American Society for Testing Materials, Philadelphia; 431 *pages,* 6 *by* 9 *inches, paperbound; available through* MACHINE DESIGN, $2.75 *postpaid.*

Intended primarily as a convenient engineering materials reference work is this latest edition of the special ASTM compilation of standards presenting the various specifications pertaining to copper and copper base alloys. Some 90 widely used standards included cover wire and cable electrical conductors, nonferrous metals, plate, sheet, strip, wire, rods, bars, shapes, pipe, tubing, alloys for sand casting, methods of testing, etc. War emergency specifications and emergency alternate provisions applicable to copper and copper alloys along with tentative standards and recommended practices provide a complete and up-to-the-minute volume.

PROFESSIONAL VIEWPOINTS

MACHINE DESIGN welcomes comments from readers on subjects of interest to designers. Payment will be made for letters and comments published

" . . . particularly like treatment"

To the Editor:

Reviewing the article on "Selecting Drives for Speed Control" by E. L. Schwarz-Kast, I feel that he has done a very good job covering the subject from a general standpoint. We particularly like the treatment showing a speed-torque characteristic curve together with a connection diagram for each of the circuits considered.

The material on series, compound, and shunt-wound d-c motors is especially well-organized and thoughtfully presented.

—J. P. SMITH, *Industrial Engineering Div., General Electric Co.*

" . . . established methods not tried"

To the Editor:

The article "Predicting Power Losses in Journal Bearings" by C. D. Wilson in the May issue of MACHINE DESIGN demonstrates the importance of the use of lubricating oil as a coolant. It is regrettable that the present knowledge of the function of an oil as a lubricant has been ignored. It has been our experience that the work of Kingsbury, Howarth, Needs, and others provides a satisfactory basis for computing power losses in bearings similar to those described by the author. No indication was given that the established methods had been tried or if they had been tried, why they failed.

To secure some comparison, the methods described in Kent's Handbook, Eleventh Edition, were used to compute the losses in the bearing used by the author as an example. Using a viscosity of 1.42×10^{-6} Reyns corresponding to a temperature of 150 F and assuming that a 120 degree arc of contact would be sufficient to carry the load, the radial clearance for minimum friction is 0.0066-in. and the resulting loss would be 30 hp. This would permit 240 degree contact with the journal surface for the cooling oil giving much better heat transfer.

The losses shown by the author are much higher and may be due largely to heat conducted from the turbine itself. This not only throws an additional cooling duty upon the oil but would prevent rational analysis of the bearing performance unless it were taken into account. If this is true the curves shown by the author are valid only when proportionate amounts of heat are added to the bearing from an external source.

Without doubt, Mr. Wilson's paper correlates the facts as found on the particular class of bearings in which he is mainly interested; i.e. fairly high rubbing speed, large bearings with large supporting structures and with relatively little heat coming from sources other than the bearing itself. The methods appear to be wholly empirical and of course quite valuable aids to design can be provided from a mass of data by purely empirical methods, but we feel that these methods do not apply, for example, to high speed, internal combustion engine bearings, and if extended to such a purpose, the methods might be misleading.

—R. J. S. PIGOTT, *Chief Engineer* and PAUL G. EXLINE *Gulf Research & Development Co.*

To the Editor:

Messrs. Pigott and Exline are correct in the statement that the methods outlined in the article are wholly empirical. The experimental data were taken for comparatively large bearings loaded by the weight of the shaft in a constant downward direction. The tests were made on generator bearings so that there was no flow of heat to the bearings from outside sources. The article stated that the data obtained from these tests has proved useful in predicting power losses and oil requirements for other sizes of similarly designed bearings. It was not intended that the curves be applied to engine bearings or to other bearings having an entirely different type of loading.

In applying standard methods of calculation to the bearing in question, Messrs. Pigott and Exline experienced the same difficulties encountered by the author in trying to correlate tests on large high-speed bearings with calculations. They used a viscosity corresponding to the outlet temperature of 150 F but the temperature of the oil in the bearing where the losses occur varies between the inlet temperature of 120 F and the outlet temperature of 150 F. Also in their calculation, they apparently only considered the loss in the 120-degree load-carrying portion of the bearing and neglected the losses which occur in the upper half. These latter losses are appreciable and the test data indicated that by relieving the bearing to reduce the rate of shear in the unloaded portion that considerable reduction in power loss can be obtained. If

half of the bearing could be completely removed, ch certainly is not desirable in a high-speed turbine ring, it is possible that closer agreement could be ob- ed with the calculated loss for a partial bearing.

When the methods of calculation for a full bearing are l as described in Kent's handbook (which is the dition most nearly applicable to the bearing in ques-) and the same viscosity (corresponding to 150 F) sed, a 78 hp loss is obtained. This is slightly higher n the value obtained in the tests.

The empirical method of estimating bearing perform- e for a particular type of bearing, as outlined in the cle, was developed to simplify the work of calculating er losses and provide a means of taking care of the ewhat indefinite viscosity term as well as other factors he bearing design which are difficult to evaluate cor- ly by purely theoretical means.

—C. D. WILSON, *Steam Turbine Dept., Allis Chalmers Mfg. Co.*

"... forgings replace castings"

the Editor:

The article entitled, "Improved Processes Widen pe of Ferrous Castings" by G. Vennerholm of the d Motor Company in June issue of MACHINE IGN has made a nice presentation of ferrous casting tice to keep progressive engineers familiar with advances in ferrous casting during recent years.

lowever, the article seems to intimate that ferrous cast- will replace many of the present day forging appli- ons and advances some illustrations where this has oc- ed. The author failed to mention that despite the critical shortage in forging capacity, it has been just as necessary to replace many castings with forgings due to the failure of the castings under severe and unpredictable stress conditions. In *Fig.* 8, there is shown a landing gear strut claimed originally a forging but changed to a casting. I have found in our plant an identical landing gear strut that was originally a centrifugal casting but due to failure in service has been produced as a forging.

The author's own words indicate the reliability of the forging. He states, "All steels originally are cast; the difference, therefore, between a casting and a forging is largely due to the effect mechanical working has in breaking up the cast structure, increasing the density of the material, and minimizing the effect of nonmetallic inclusions." He further states, "In order to arrive at equal properties regardless of method of manufacture it will, therefore, be necessary to introduce external or other forces which will reduce grain size, minimize the tendency towards shrinkage cavities and in general increase the density, thereby simulating effects of mechanical working."

It is entirely possible and probable that new and better methods of metal working will be developed in the future, and from our present knowledge of metals, the new methods will probably be improved methods of forging practice. It does not seem logical that simulated methods of metal working will produce a product as good as forging any more than simulated pearls approach in quality the genuine pearls. The critical shortage of forging capacity during the war period is the best indication that there is no adequate substitute for the forging in its ability to serve under conditions of unpredictable loads.

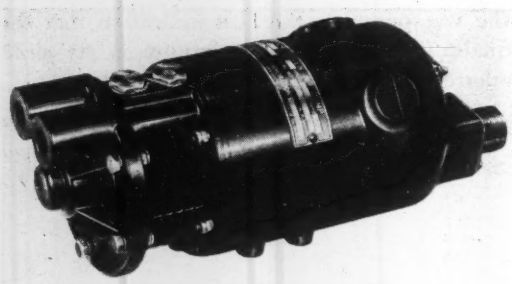
—W. NAUJOKS, *Chief Engineer The Steel Improvement & Forge Co.*

"He wants to know at what school the Jominy Test is being given"

NEW PARTS AND MATERIAL

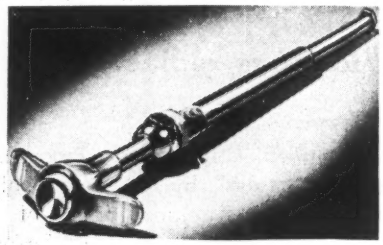
Explosionproof Dry-Air Pump

LIGHTWEIGHT motor-driven dry-air pumps of Eclipse-Pioneer Division, Bendix Aviation Corp., Teterboro, N. J., will be of interest to the aviation industry and its allied fields. This explosionproof pump requires no lubrication and is designed to provide air pressure or suction for camera operation, fuel tank pressurization, ignition harness pressurization, instrument control, gas detector operation, and radio harness pressurization. It provides a theoretical air flow of 4.1 cfm at 10,000 rpm, and is driven by an integral 0.2 bhp 27.5 volts direct-current, explosionproof motor. Rated capacity is 0.018 lb per min air flow at 11.1 in. Hg Abs inlet pressure, maintaining 31 in. Hg Abs discharge pressure. Maximum operating characteristics include: Current draw, 15 amp; pressure differential, 20 in. Hg; discharge temperature, 300 F; minimum flow, 0.01 lb per min. Since the pump requires no lubrication, it provides air, free of oil contamination, and can be mounted near its supplementary equipment or in inaccessible places on horizontal stabilizers, dorsal fins, wings, etc. The pump is a rotary, single-vane type, the vane being held against the rotor by pressure exerted through dual helical springs. Having a finned rotor housing, the pump incorporates an automatic electrical overload protection. Weight of the pump is 4.75 lb. Overall dimensions are 8 21/32 x 3 17/32 in.



Tension Lock Control

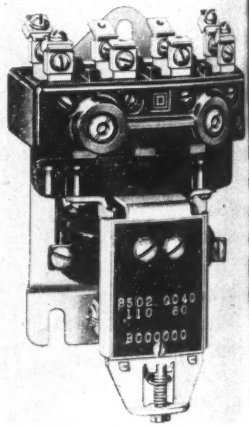
OFFERING A positive lock for difficult control jobs, the new push-pull tension lock control of Arens Controls Inc., 2253 South Halsted St., Chicago, will hold load pressure which can be applied by hand. It can be used in combination with rods and cables as well as other flexible or rigid push-pull remote controls. Consisting of a ½-in. steel sleeve with all operating mechanism contained in it, the new lock control is compact and weighs 8 ounces. The aluminum T-shape control knob is designed for ease of operation and locks the control in any position of travel. Pulling out the control head releases the control to any desired position, as the wedge key



inside the control wedges itself against the wall of the outer sleeve preventing the inner sliding member from moving back. Pushing the button on the head of the control depresses a spring which actuates the wedge to give wall clearance from the outer sleeve, permitting the sliding control member to be moved.

Convertible Contactor

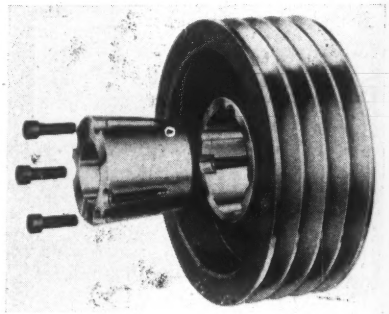
AN OUTSTANDING feature of the new Size 00 Type Q contactors, just announced by Square D Co., 4041 North Richards St., Milwaukee 12, is that they can be changed easily from normally-open to normally-closed without additional parts. This conversion is performed by removing a movable contact assembly, inverting it, and putting it back in place, involving no additional parts. Both accessibility and compactness have been combined in the new contactors. All terminals have provision for two wiring clips. A new-type contact bar and guide assure substantially increased life. Double-break silver contacts are replaced readily if and when prolonged, frequent operation makes replacement necessary. Suitable for mounting on steel panels, these



ctors are available with two to six poles in any com-nation of normally open and normally closed contacts. tings are 600 volts, alternating current, max; 10 amp en, 9 amp closed.

V-Belt Sheaves Offered

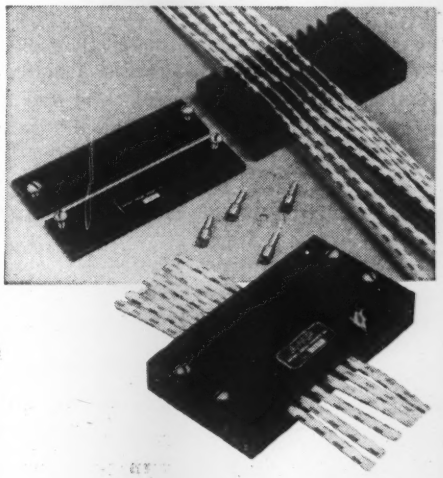
NTRODUCED BY Dodge Mfg. Corp., Mishawaka, Ind., e Taperlock V-belt sheave represents a new means of ickly mounting and demounting V-belt sheaves. To tall the sheave, it is necessary to slip the sheaves and shing assembly on the shaft and tighten two or three cking screws, depending on the size of the sheave. rews are in threaded engagement with the sheave hub d free in the bushing groove. As the screws are tight-ed, they push against the tapered bushing, forcing it to the tapered bored hub. This causes the bushing contract and wedge between the hub and shaft on hich it is installed. To remove the sheave, locking rews are removed and one or two of them are inserted jack screw holes partially in the bushing and partially



the hub. The portion of the jack screw hole in the ushing is threaded and that in the hub portion is un-hreaded. As screws are tightened, the bushing is de-edged and the sheave is free for removal from the shaft. dvantages offered in this construction include a mount-g of minimum dimensions for accommodation of screws nd their connection with hub and bushing. It also ermits the use of flangeless bushing and eliminates ex-ension of either hub or bushing or any collars or pro-uding parts. This reduces weight and facilitates mount-g and demounting. Wedging action provided gives the quivalent of a shrunk-on fit on the shaft whether it is tandard or normally undersize. The bushing extends he entire length of the hub providing a full bearing urface.

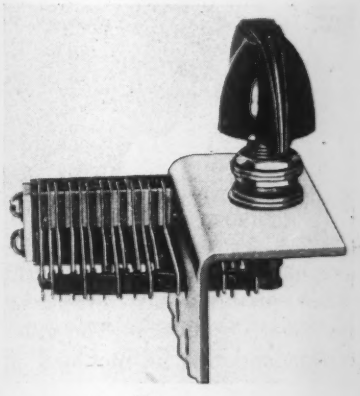
Solderless Connector Strips

TWO NEW TYPES of connector strips have been made vailable by Aircraft-Marine Products Inc., 1521-31 North ourth St., Harrisburg, Pa. These include the single-idth and double-width strips which incorporate a knife-witch disconnect terminal design. The single-width trip, adapted to use with the AMP pre-insulated splicing erminal, requires no insulation sleeving. Knife-switch art of the permanent member extends outside the strip, and connection and disconnection are made without removing the cover of the assembly. The double-width strip in which the disconnect ends are enclosed is locked and insulated by the cover, one-half of which is indepent of the other half. Disconnection is made by unscrewing one-half of the cover to expose connections. Permanent disconnect member of the splice has an extended tongue fitting into the connector strip. This member terminates in a knife-switch stamping to which ter-



minals of knife-switch design may be connected or disconnected by holding the free terminal end vertically in contact with the strip member and then pulling back. This results in a four-point contact.

Heavy-Duty Turn Switch



KNOWN AS Type 043T-2, a heavy-duty turn switch manufactured by Donald P. Mossman Inc., 612 North Michigan Ave., Chicago is particularly suitable for radio and audio application. Mounted singly, complete isolation of radio and audio frequency carrying elements is achieved. Action of the switch is rather unusual in that both frequency ranges can be controlled in the same unit assembly. The switch is mounted in a cast steel housing. Mounting bracket fits into a final electronic unit as a mounting for the switch, and as a shield between various frequencies. Overall resistance at soldering lugs is below 0.007-ohm. Essentially a two-position switch, and developed to meet severe operating conditions, it is assembled for locking or nonlocking action. It also may be provided with an extra long bushing and gland nut where extreme moisture conditions exist. All basic content forms may be

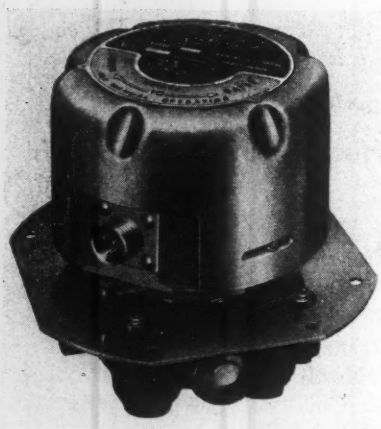
used, and combinations developed to provide for a greater variety of circuit arrangements. The switch is rated at 110 volts, alternating current (non-inductive).

Welding Rod Offered

FOR HARD-SURFACING operations where extreme hardness and resistance to shock and corrosion are required, the new super-hard and tough alloy steel welding rod is composed of high carbon, high chromium, high molybdenum, tungsten and vanadium. This steel, offered by American Manganese Steel division of American Brake Shoe Co., Chicago Heights, Ill., has a brinell hardness of 575 to 675, depending on the dilution of the metal.

Electric Actuated Hydraulic Valve

RECENTLY INTRODUCED is the Motordyne series of valves, developed by the Pacific Division of Bendix Aviation Corp., North Hollywood, Calif., to meet a growing demand for a simple electric actuated hydraulic selector valve. A high-speed electric motor driving through a series of reduction gears actuates the valves in either direction, in approximately ¼-second. All spring-returns, current-draining holding coils, and all small pilot valves and orifices have been eliminated. A manual override in the new valves provides easy emergency operation by rotating the cover of the unit. The valves are not affected by vibration and can be mounted in any position. Hydraulic steam pressure is not required to hold the valve open, which permits emergency or hand pump operation. The complete unit weighs 2.86 lb for the ⅜-in. tube size Motordyne valve.

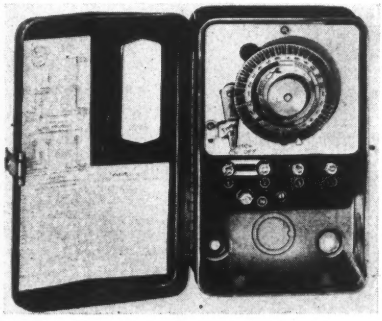


Pump Offers Finger-Tip Control

NO LARGER than a man's two fists, a new aircraft type pump of Pesco Products Co., 11610 Euclid Ave., Cleveland 6, supplies hydraulic power for controlling tractor-mounted implements. The hydraulic pressure provided will raise or lower, at a flip of a handle, plows, harrows, cultivators and other implements mounted directly on the tractor. This tractor pump is an adaptation of the company's gear-type, pressure-loaded pump for aircraft use. Some of the advantages claimed include high overall efficiencies through the full range of operating temperatures that might be encountered, and long service life accomplished by an automatic adjustment of end clearances which compensates for wear. The pump is said to have demonstrated its ability to function at temperatures from subzero to tropical.

Motored Time Switches

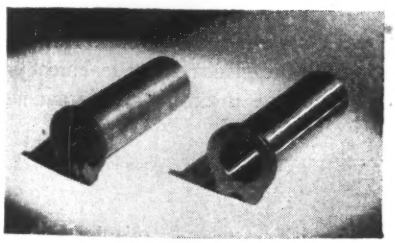
MOST RECENT improvement in three 300 Series time switches of Paragon Electric Co., 37 West Van Buren St., Chicago 5, is the inclusion of an industrial type, self-starting synchronous motor. Operating advantages of this type motor include capillary oiling system, practically instantaneous self-starting at full rated load, gear reduction sealed to exclude dirt and dust, and low power consumption. Light in weight, small and compact in design, the switch has a capacity of 3000 watts per pole with easily mounted, accessible terminals, skip-trip feature, knockouts on three sides and bottom, and two-bearing plate construction. Some uses of the switch include the control of fans, stokers, oil burners, blowers, pumps, valves, motors, etc.



Electrical Insulating Board

ONE HUNDRED per cent noncotton cellulose electrical insulating board with better characteristics than one hundred per cent rag board, known as DUROK, has been announced by Rogers Corp., 36 Mill St., Manchester, Conn. Dielectric strength of the material ranges from 400 to 600 volts per mil. Methanol and naphtha extractables, important in hermetically sealed refrigerator motors, are 0.0 to 0.12 per cent and 0.02 to 0.08 per cent. Tensile, elongation, tear and Mullen tests indicate that the new board is at least 15 per cent stronger than the company's 100 per cent rag board. Because of complete absence of chemical treatment or sizing, the new material is neutral, has good heat-aging characteristics, readily dries out with a shorter baking cycle and absorbs insulating varnish. The material is made by laminating many thin, continuous layers while wet under high pressure, without adhesives

The Case of the Hidden Cost



Precision Pays . . .

A few cents saved on machining of the bearings usually results in expensive damage to the shaft. A little more emphasis on quality and precision pays off with greater performance, lower cost operation and longer bearing life.

● In 1935 there were no shortages. Competitive selling was the order of the day. At that time a machinery manufacturer found a way to save ten cents on each of four bearings for one of their products. Instead of the *precision* made Johnson Sleeve Bearings, they substituted a rough-machine finished bearing, made from an oxidized alloy of uncertain analysis, cast in their own foundry.

Yet the total cost of the machine went up four dollars!

The reason was obvious. On the assembly line it required hours . . . instead of minutes . . . to install the bearings. In some cases the bearings had to be hammered into place. Most of the bearings had to be reamed after installation. A few required immediate replacement due to breakage from the stress of installation. This substitution caused considerable customer dissatisfaction through increased service costs . . . difficult and frequent replacement.

There are many and various ways of cutting costs in manufacturing . . . but no sensible method involves a compromise with quality. No part in any motive unit is more important than the bearings. Great care should be exercised in selecting the type for each application . . . in specifying the tolerances . . . the finish and the alloy. The easiest way to determine the correct answers to your bearing problems is to call in a Johnson Engineer. There is one located near you.

JOHNSON BRONZE COMPANY
525 S. MILL STREET NEW CASTLE, PA.

Over 40 Years
Exclusive Bearing Experience

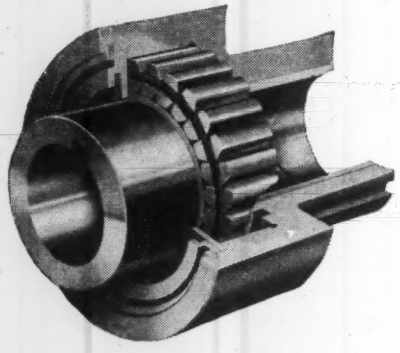
JOHNSON
SLEEVE BEARING HEADQUARTERS
BRONZE

BRANCHES IN 18 INDUSTRIAL CENTERS

chemicals, then drying without any tension. Stock sheet sizes are 36 x 48 in. and 36 x 24 in., with the grain direction parallel to the second dimensions. Thicknesses now available are 0.015, 0.020, 0.025 and 0.030 in. The company also fabricates the material into motor slot cells and other insulators and structural pieces.

Overruning Clutch

CONSISTING OF cylindrical inner and outer races, with the annular space between them filled with formed sprags, an overrunning clutch has been introduced by The Gear Grinding Machine Co., 3901 Christopher, Detroit 11. Contact with both surfaces of the clutch is maintained by an energizing annular spring at each end of the sprags. All sprags are rotated at the same time when torque is applied, gripping both inner and outer races to form what is prac-



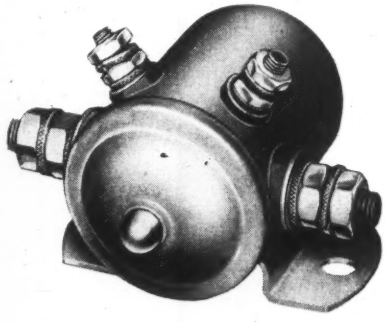
tically a single piece of metal. When torque is removed, sprags release. Positive engagement and disengagement may be made hundreds of times per minute. Localized stress is reduced to a minimum due to the large number of sprags. Torque-carrying capacity of the clutch is equal to the torque-carrying capacity of any shaft which has a diameter less than the diameter of the inner race.

Processed Cotton Cloth

DESIGNED FOR diaphragm uses such as in fuel pumps, a specially processed cotton cloth has been developed by Irvington Varnish & Insulator Co., Irvington 11, N. J. The new cloth has high bursting and tearing strengths, remains flexible and offers recovery over a wide range of operating temperatures.

Solenoid Contactor

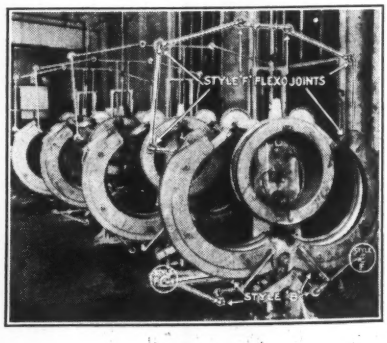
DIRECT-CURRENT solenoid contactors, completely enclosed for protection are now being produced by R-B-M Mfg. Co., Div. of Essex Wire Corp., Logansport, Ind. Known as Type 71 this sturdy compact unit is for low-voltage power application on either stationary or mobile apparatus. To provide complete protection against dirt, moisture, vermin and other destructive elements, magnet coil and contacts are fully enclosed in a magnetic iron ca with cap spun over. All metal parts are plated for f ther protection. The contactors are available with sing



pole, normally-open, double-break contacts, rated at 10 amp continuous; 300 amp in-rush at 32 volts, direct cu rent, and below. Copper contacts are standard, thoug special alloys are furnished. The approximate size of th contactors is 3¼ x 3 x 2½ in. Average weight is 14 o Although not designed for Air Corps specifications, th unit will pass 10g vibration or acceleration tests, and wit stand vibration and shocks normally encountered in pa senger cars and trucks.

Flexible Joints Announced

DEVELOPMENT OF Flexo Joints by Flexo Supply Co 4221 Olive St., St. Louis 8, makes possible flexible pip connections to moving machinery under high or low pre sure, heat or cold, with steam, air or fluids. Having th ability to swivel through 360 degrees, these leakproof joint consist of four parts, each one interchangeable and mad

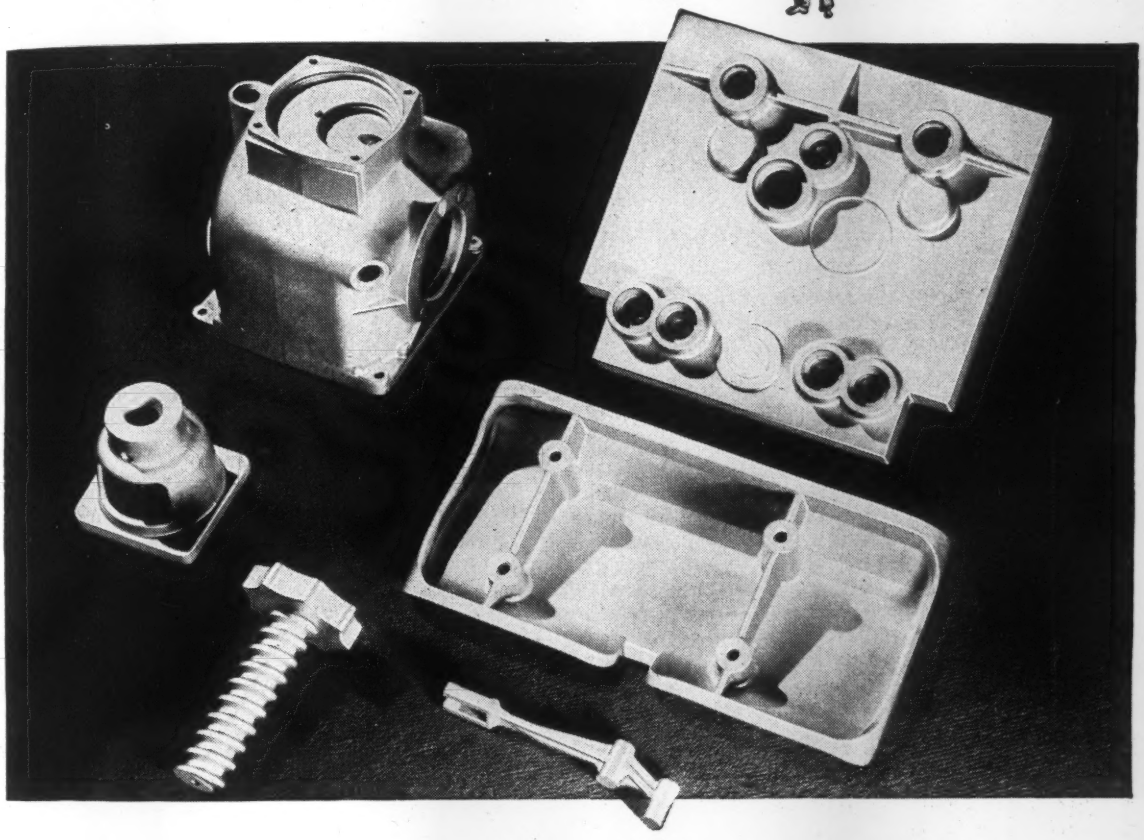


in all standard pipe sizes from ¼-in. to 3 in. with threaded ends.Four different styles are available. The standard joint is bronze, designed for working pressures up to 250 lb and temperatures not exceeding 500 F. For high pressures up to 1350 lb and temperatures above 500 F the joints are of cast steel. Installed in the same manner as any pipe fitting, the joints may be used for practically any service by varying the composition of the inner seal.

Standard Grease Fitting

AVAILABILITY HAS been announced by The Lincol Engineering Co., 5701 Natural Bridge Ave., St. Lou 20, of its new grease fitting known as the Bullneck. Orig

you want them light...strong... shock resistant



rn to Magnesium alloys for high quality die castings

It's basic that you turn to die castings for definite qualities: accurate dimensions, a minimum of machining, good surface finish, low cost. But don't stop there—add the benefits of strong, lightweight magnesium alloys to complete a job that gives you maximum quality . . . economy . . . speed.

Magnesium alloys offer weight economy that is unique among structural metals; at the same time they have high strength and resistance to shock. These magnesium advantages—together with the benefits of die casting—form a combination that is doing an increasingly important job throughout industry.

How would magnesium alloys work in your own product? For a sound, dependable answer, we invite you to call upon the accumulated experience of many years' work in Dow's own shops. Get in touch with the nearest Dow office; a technically trained magnesium consultant will be assigned to work with you.

MAGNESIUM

THE METAL OF MOTION

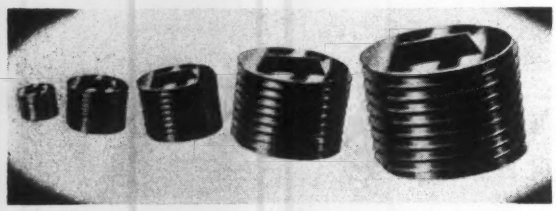
GNESIUM DIVISION, THE DOW CHEMICAL COMPANY, MIDLAND, MICHIGAN

York • Boston • Philadelphia • Washington • Cleveland • Detroit • St. Louis • Chicago • Houston • San Francisco • Los Angeles • Seattle

inally developed for use as standard equipment on heavy military combat and transportation vehicles, the fitting has such features as a flush ball check, larger grease passage, bearing pad for coupler jaws, and a noncollapsible spring which cannot be forced out. It is machined from steel bar stock, hardened to a uniform degree throughout, and has a heavy zinc plating to withstand the severe usage encountered on heavy equipment.

Countersunk Plastic Pipe Seals

PLASTIC PIPE seals and thread protectors in countersunk pattern, announced by American Molded Products Co., 1644 North Nonore St., Chicago 22, offer strength and lightness, as well as toughness of plastic. The plastic takes accurate and durable threading, is noncorrosive, dielectric, and excludes moisture, oil, dirt, grit, etc. Square sockets of the new countersunk pattern are of dimensions



to fit commercial square bars of standard sizes. Dimensions are the same as the maximum size of cold-rolled square steel bars given in ASTM specifications. Sizes available include ⅛, ¼, ⅜, ½, ¾ and 1 in.

High-Tensile-Strength Steel

ANNOUNCED RECENTLY by Horace T. Potts Co., East Erie Ave. and D St., Philadelphia, a new steel is furnished in heat-treated condition with a tensile strength of 125,000 psi or better. It is readily machinable, and has unusual uniformity in cross-sectional hardness. It is suitable for stressed or wearing parts with unequal cross sections. According to the company, this material known as Elastuf Type A-2 has been used for crankshafts, gears, shafts and miscellaneous machine parts.

Three-Purpose Electrode

DESIGNED TO produce horizontal fillet welds with flat or slightly concave profiles and concave fillets in the flat position, as well as deep fillet and deep groove, a new combination-type welding electrode is being marketed as Airco No. 315 by Air Reduction Sales Co., 60 East Forty-second St., New York 17. Applications for the electrode include pressure vessels and their connections, heavy machine weldments, structural assemblies and practically all heavy steel assemblies where high weld quality is important. It may be used with conventional technique, employing normal currents, under which conditions medium penetration is obtained. Deeper penetration is s when deep fillet technique is used with the high c recommended for this procedure.

Combustion Engine Lubricant

PARTICULARLY adaptable for cold weather use, internal combustion engine lubricant has been dev by Carbide & Carbon Chemicals Corp., 30 East second St., New York 17. It can be manufactured desired viscosity and is wax-free. Pour-points vary −30 to −80 F and flash points range from 300 F a The materials have densities approximating that of Carbon residue values are less than 0.01 per cent, less of viscosity. Lubricant is characterized by low c of viscosity with change in temperature, having vi indices in the range of 140 to 160. Sludge and v formation in engines is practically eliminated. The cant is manufactured in two types, water soluble water insoluble, the latter type being used for lubr internal combustion engines. Other applications i lubrication of refrigerating machines and other ma operating under conditions of low temperature or a nonsludging oil is required, and as hydraulic fluid tile lubricants, etc.

Complete Line of Control Devices

A COMPLETE LINE of control devices embody unique snap-action arrangement which lends itself t curate control of temperature, pressure, humidity mechanical displacement, has been announced by Paul Henry Co., Thermal Div., 2037 South La Cie Blvd., Los Angeles 34. Other features of the controls Double-break contacts; applicable range from −1 600 F; enclosed contacts; single and double-throw; s

pole or independent circuit double-throw; resistant t bration; low thermal lag; tamperproof; adaptable to mounting means; contact openings from 0.010 to 0.06 as desired; operating parts in balance thermally as w geometrically; and calibration not affected by und overheat conditions. These devices are marketed by company under the name of Cam-Stat, and are furn with operating differentials running down to as low degree Fahr. The model illustrated is a C therm

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We in the plastics industry have learned a lot from this war. We've had to. The constant demands for better equipment . . . stronger . . . more precisely built . . . and faster . . . have resulted in amazing improvements all along the line. New materials . . . new methods . . . new techniques. With the result that we are accomplishing today things that were only a hope a short time ago.

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And all this is on top of more than two decades of peacetime experience in plastics.

This can mean a great deal to your peacetime products. You'll be able to do more things with plastics than ever before . . . and do them better . . . providing stronger sales appeal and greater customer satisfaction.

Today, of course, war needs still come first. But, in the meantime, you'll find it good business to learn about the postwar possibilities of molded plastics. Why not call in a CMPC Development Engineer . . . today?

* * *

FREE! Our new book, "The Story of Plastic Molding," is packed with valuable information . . . fully illustrated with photos, charts, and diagrams . . . facts and figures you should have. Write for your FREE copy today.

CHICAGO MOLDED PRODUCTS CORPORATION

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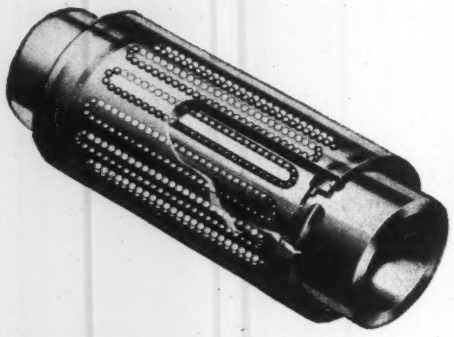
weighing less than one ounce and rated at 10 amp 115 v or 28 v, alternating current. Other models can be supplied to suit specific thermal control problems.

Synthetic Rubber Hose

OFFERING INCREASED resistance to heat and pressure, a new synthetic rubber hose, introduced by United States Rubber Co., Rockefeller Center, New York, is designed to withstand temperatures up to 250 F in oil lines and up to 300 F for installation in cooling systems. Resistance to pressure in hose one inch in diameter is double that of hose formerly used. Strength is increased proportionately in other sizes, ranging from one-quarter inch to two and one-half inches in diameter. A principal feature of construction is a new high-strength carcass built with a chemically-treated cotton yarn, and a special heat-resistant synthetic rubber.

Revolutionary Ball Bushing

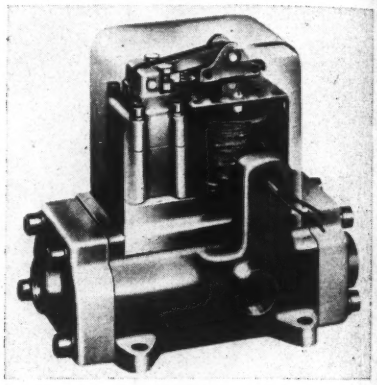
PERMITTING UNLIMITED travel of reciprocating mechanical members that may be either round or square, or variations of these shapes, a new ball bushing has been developed by the Thriftmaster Division of Thomason Industries Inc., 29-05 Review Ave., Long Island City, N. Y. Advantages gained by using ball bearings for rotating parts can now be obtained on sliding members. Basically, the bushing contains within it a series of ball circuits; one side carrying the bearing load, and the other returning



the balls in a clearance provided in the outer race member of the bushing. The continuous bearing prevents cocking or binding on the shaft because the bearing balls remain centered under load. Rolling contact, plus sealed-in lubrication enables a long life of antifriction precision alignment. System of ball circuits can be changed for varying load capacities and shapes of bearing members, making it possible to have a bearing of considerable length or of a square, hexagon or octagonal section.

Solenoid-Controlled Valve

INTRODUCED BY Numatics, Milford, Mich., a valve with a fluid lever represents a new engineering adaptation of a well-known principle. The design utilizes compressed air to boost the solenoid action, giving high-speed c of any single or double-acting air cylinder up to pipe capacity. This makes possible the use of a small solenoid, drawing only 3.6 amp at 110 volts models regardless of valve size. The higher produ efficiency, it is claimed, comes from diverting to op ing advantage a portion of the air that passes th the valve, controlling the ratio of air balance so



the remaining effort can easily be handled by a s solenoid. The new valve is also suitable for two- sure control. A 4-way model can be readily conv for 3-way use by plugging one port. Straight-lin flow minimizes pressure drop, simplifying installatio

Electrodes for High-Tensile Steels

ARC-WELDING electrodes for welding low-alloy, hi tensile steels have been announced by the Electric W ing Division of the General Electric Co. Known as T W-56, the electrodes operate on either alternating or di current, reverse polarity, and the range of current is s ficiently broad to cover a wide range of plate thickn A medium-long arc is recommended for best results. El trodes can be used in flat, vertical, and overhead p tions. Available in sizes ⅛, 5/32 and 3/16-in. in di eter, the electrodes meet requirements of AWS Cla E7010/E7011, and comply with the Navy Bureau of Sh specifications 46E2.

Rust Preventive Coating

DEVELOPED BY Witco Chemical Co., 295 Madis avenue, New York 17, a new rust preventive coating protection of metal parts and equipment during stora shipment and in some cases in service is known as Wi No. 673 rust inhibitor. It is a cold-dip, rapid-drying co ing that may be applied either by dipping or spraying its viscosity is comparable to that of water. Conform to Ordnance Specifications AXS-673, Rev. 1, Amend. the coating is nonabrasive, noncorrosive and easily moved with ordinary solvents. An outstanding feature the coating is its high melting point—in excess of 250 grees Fahr.—and its ability to remain flexible at tempe tures of 20 degrees below zero.

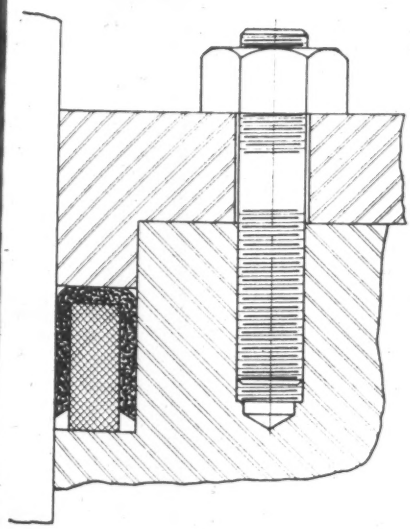
A 36" COLLAR FOR AN IRON NECK

Vim Leather "U" Packing holds 6000 lbs. pressure in this Baldwin-Southwark Press

Mighty presses need mighty packings to hold the pressure and assure proper seal. This press uses a VIM Leather "U" Packing 36" in diameter, filled with flax, as shown in sketch at left. It's doing fine work for its user.

VIM Leather Packings, regardless of type ("V," "U," Cup or Flange) do a fine job for press manufacturers. They are the choice of most hydraulic machine builders, because they last longer and they're designed right.

Houghton hydraulic engineers will help you on application and design, if you'll put your problem up to them. Write for the abbreviated VIM packing catalog for your file.



Cross section of packing design on Baldwin-Southwark press, showing VIM leather "U" Packing with flax insert.

E. F. HOUGHTON & CO.
303 W. Lehigh Ave., Philadelphia 33, Pa.

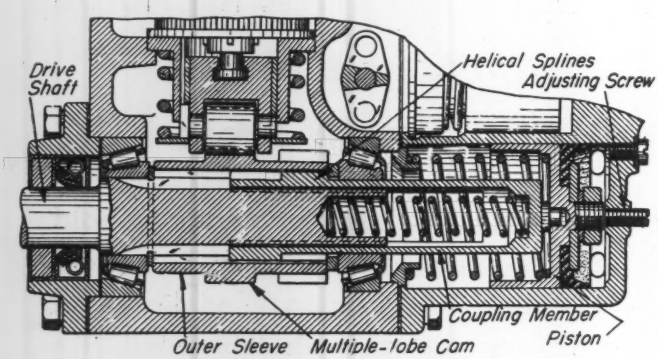
HOUGHTON'S *Engineered* **VIM** *Leather Packings*

Noteworthy Patents

Adjusts Cam During Operation

A COUPLING which transmits rotative power and permits a radial adjustment of an outer cam sleeve for timing purposes is covered by patent 2,372,180 recently assigned to The Timken Roller Bearing Co. Designed primarily for hydraulic control of the cam sleeve setting, the device is particularly suited to driving and timing such mechanisms as fuel injection pumps for compression ignition engines.

Designed to rotate freely within a piston actuator, the piston rod coupling member, in the accompanying illustration is keyed to and driven by an externally pow-



Hydraulic pressure operating the piston of this device effects an angular advance or return of the multiple cam

ered drive shaft. Helical splines on the coupling member fit within mating helical splines on the sleeve, the outer face of which in the coupling shown is a multiple-lobe cam.

Timing of the cam action is accomplished by application of hydraulic pressure to the piston actuator. Axial movement of the coupling member thus created imparts an angular advance in the position of the cam lobes relative to the drive shaft. Retarding or advancing the timing of fuel injection in the device illustrated is accomplished automatically by utilizing the varying pressure of the fuel supply pump to control the hydraulic piston.

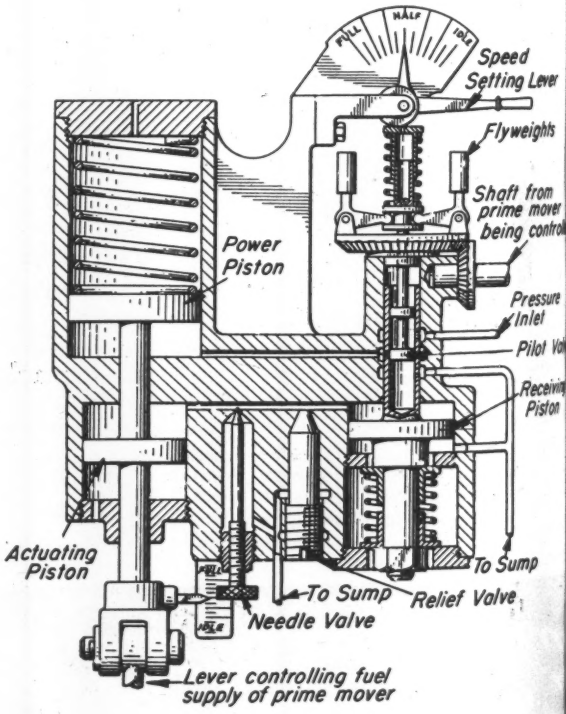
The design may be altered to serve a great variety of requirements by merely substituting the proper cam and return springs. Manual adjustments are provided for by the adjusting screw abutting the end of the actuator piston.

Governor Insures Smoother Control

WITH what amounts to an adjustable hydraulic linkage between flyweights and throttle control, the governor in the accompanying illustration is designed to maintain more constant speed of a controlled prime m than has been possible heretofore. Covered by pa 2,371,793, it was recently assigned to General Mo Corp.

Sudden increase in prime mover speed throws the weights outward, raising a pilot valve and uncove ports in the valve sleeve to permit flow from belo power piston, across the unit, to a sump line. With duced holding pressure below it, the power piston forced downward by its spring, moving the actuating ton down with it. The reduced pressure thus effe in the chambers above the actuating and receiving pi is less than sump (atmospheric) pressure. Therefore receiving piston rises, as does the attached valve sl When the upward movement of the receiving pistor stopped by contact of the two flanged sleeves at its b the relief valve opens, equalizing the pressure above below the receiving piston and permitting its spring return it and the valve sleeve to the position shown (n mal). Simultaneously the pilot valve is moved downw by the inward movements of the flyweights owing to reducing speed of the prime mover.

Continued reduction of speed moves the pilot va down to a point where the ports that permit flow fr the constant-pressure pump inlet to the power piston open. Consequently the power and actuating pist move upward, increasing the pressure in the chamb above the actuating and receiving pistons. This pr



Hydraulic operation controlled by conventional f weights obviates hunting characteristics in this gover

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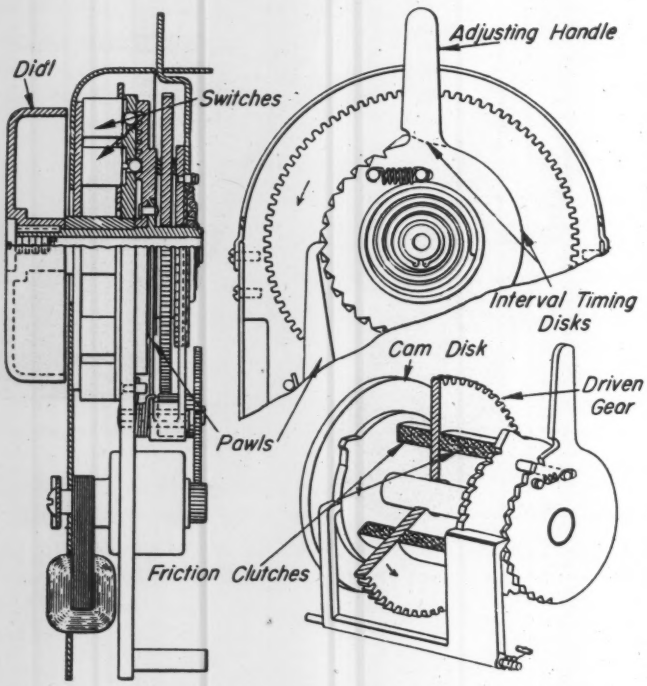
JONES & LAUGHLIN STEEL CORPORATION PITTSBURGH 30, PENNSYLVANIA

sure forces the receiving piston and pilot valve sleeve below normal position until flow from the constant-pressure pump is blocked, stopping further upward movement of the power piston. Since the final upward movement of the power piston feeds more fuel to the prime mover, a speed-up occurs, urging the flyweights outward, resulting in gradual upward movement of the pilot valve. The valve sleeve also moves upward so that the flow from the constant-pressure pump continues to be blocked and thus no further movement of the power piston takes place. A similar cycle of valving takes place when the prime mover is subject to sudden or gradual reductions in speed.

Automatically Times Washing Cycle

AN IMPROVED timing control for a sequence of operations providing an adjustable duration for one sequence is covered by patent 2,374,590 recently assigned to the General Electric Co. Such a sequence control is particularly adapted to timing the operational cycles of automatic washing machines wherein it is highly desirable to have a washing cycle of variable duration independent of the other fixed operations.

Referring to the accompanying illustration, the indicating dial shown on the left is set to the position marked "start" for operation. This moves a cam into proper position to release a switch actuating ball and open a starting switch. Operations are then carried out in sequence at a time determined by the timing motor speed, design of the cam surfaces and positions of the balls on the cam. When the



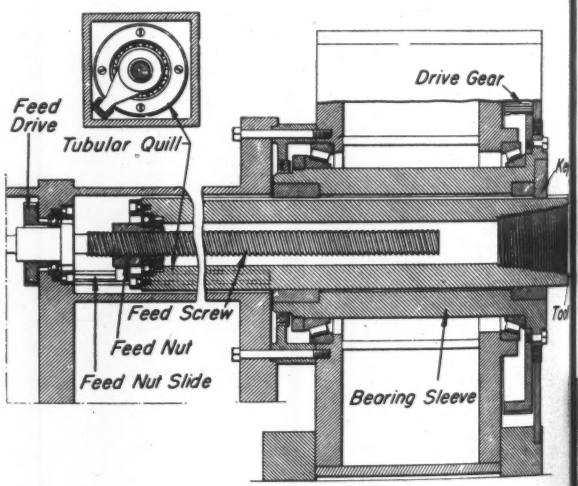
Unique friction drive on sequence timing mechanism allows resetting or changing during operation

washing or other adjustable-length operation is reached, the cam is stopped by a double pawl and this action simultaneously releases and starts rotation of a pair of interval timing disks. The interval of dwell thus produced in the rotation of the cam is governed by the setting of adjustable handle. A cam projection on the inner of two timing disks engages and lifts the double pawl to release the cam, stop the timing disks and continue the tomatic sequence of operations to conclusion.

The adjustable handle of the interval timing disk is arranged that the inner timing disk can be moved in either direction at any time. Likewise the indicating and ting dial can be changed to start any one of the various operations in the sequence at any time during the cycle. This is made possible through the design of the driving gear which floats freely on the main shaft driving both the cam and the interval timing disks by means of a pair of friction clutch rings. A spring and thrust ring at the end of the shaft maintain adequate driving engagement between the clutches and the gear.

Spindle Has Internal Feed Screw

PARTICULARLY adaptable to boring heads, an improved type of machine power spindle is shown in the accompanying illustration and is covered by patent 2,38[illegible] 292 recently assigned to R. G. LeTourneau Inc. Power to operate boring tools and cutters, this spindle can be fed into the work, held or retracted as required.



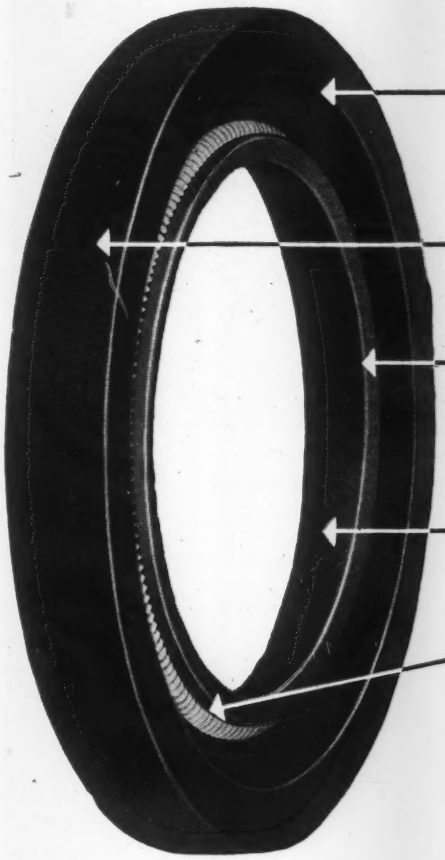
The internal feed screw for this spindle is independently driven and provides a compact, well sealed assembly

The tubular quill or spindle is keyed to and driven by a heavy-duty bearing sleeve through a drive gear attached to the sleeve flange. Actuation of the spindle in and out is accomplished by means of a lead screw operating through a lead nut attached to the end of the spindle with a ball bearing. A channel-shaped slide engages an extension of the nut to prevent rotation. An independent feed gear train powers the feed screw to provide controlled axial advance into the work and subsequent retraction.

Assembly of the unit is such that the entire mechanism is sealed to retain lubricant and exclude foreign matter. To assure maximum axial advance of the spindle and keep the keyway as clean as possible, the driving key is located at the face of the bearing sleeve in an easily accessible position.

NEW TYPE *non-metallic* OIL SEAL

simplifies design problems... reduces bearing maintenance



One-Piece Precision Molded Body—
tough, long-wearing and highly resistant to grease and oil. Entirely non-metallic—can't score.

Rigid Heel—
made of a dense resin-bonded fabric to insure a press fit in the packing recess.

Flexible Lip—
an integral part of the seal. Makes possible accurate control of pressure against shaft by means of self-adjusting garter spring.

Large Bearing Area—
reduces wear on shaft to a minimum.

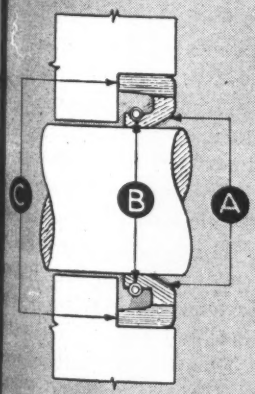
Self-Adjusting Garter Spring—
permits accurate control of pressures and provides a positive contact with shaft at all times. Special spring stock is available for extreme corrosive conditions.

THIS new J-M "Clipper Seal" offers distinct advantages both from the standpoint of machine design and protection to bearings in service.

Its one-piece precision-made body, concentrically molded and non-metallic in construction, permits liberal machining tolerances. Its simple, compact shape makes possible a light flange section that effects compactness of machine design.

In service, these features of the J-M Clipper Seal provide a positive lubricant-retaining, dirt-excluding seal . . . automatic in its operation . . . adaptable to a wide range of conditions . . . and highly resistant to most forms of corrosion.

Johns-Manville Clipper Seals are made in sizes for shafts from 1 5/16" to 37" diameter, in both endless and split types. Special designs are available where unusual temperature, pressure or chemical conditions require. For further details, write Johns-Manville, 22 East 40th Street, New York 16, New York.



Here's how it works:

The flexible lip (A) is held in light but firm contact with the shaft by means of the garter spring (B). Pressure on shaft is carefully pre-determined to minimize wear, yet effectively seal against leakage. The rigid heel (C) provides a press fit in the cavity, assuring a tight lubricant-retaining seal at this point also.

Johns-Manville **PACKINGS & GASKETS**

Frank C. Norris

Lonnis Denison

Ronald B. Smith

MEN...of...machines

FRANK C. NORRIS, formerly director of production, has recently been made vice president in charge of engineering and manufacturing for the Denison Engineering Co. Associated with the Denison organization since its inception, Mr. Norris started as a lathe operator for the Cook Motor Co., later purchased by the Denison company. He advanced as the company grew, successively serving as service representative, plant superintendent, general superintendent and assistant general manager. He held the position of vice president and general manager of the Budd-Ranney Engineering Co., when that company became a totally-owned subsidiary of the Denison Engineering Co.

LONNIS DENISON, previously assistant general manager, has been made vice president and assistant general manager of Denison. He has been active in the company's management since 1942, having first served as assistant production manager, then as manager of the company's research laboratory and later as acting director of engineering and member of the management committee.

RONALD B. SMITH, who since 1937 has been associated with the Elliott Co., has recently been elected vice president in charge of engineering of the company. Mr. Smith received his degree of Bachelor of Science from the University of Washington in 1930, and three years later his Masters degree in engineering from the same university. In 1936 he was awarded the degree of science by the University of Pittsburgh. After graduate work in electri engineering at the University of Penn vania, and in mathematics, physics, applied mechanics at the University Michigan, he was selected for spe training by Westinghouse Electric Co from whose mechanical design school is also a graduate. Mr. Smith then joi the Elliott Co., where as director of search and development he was respo sible for the design and construction the first gas turbine power unit built the United States for marine applicati He also is credited with the develo ment of the Elliott-Buchi turbocharg now used on four-cycle diesel engi The research activities of the compa which Mr. Smith has directed since election as vice president in charge engineering, included wartime engine ing problems with approximately six technical engineers. Mr. Smith is a author and author of a number of te

Modern STEEL CASTING METHODS
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These 28" ball-and-socket joints for a pontoon dredge line very aptly illustrate two vital aspects of PSF production: the inherent soundness and uniform structure of PSF steel castings; and the close-tolerance machining and expert assembly work that are a strong part of the service we're equipped to render. PSF's advanced foundry techniques and laboratory controls, amplified by complete and highly modern finishing facilities, constitute a background for true quality work—steel castings that will meet the most exacting conditions your jobs may impose. ● Let us figure on your casting requirements.

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nical papers, and is a member of the American Society of Mechanical Engineers. He has served on this society's Power Test Codes Committee, Coordinating Committee on Gas Turbines, and the Committee on Industrial Instruments and Regulators. As a member of the Society of Automotive Engineers, he has served on the Aircraft Engineer Engineering Activity Committee.

♦

L. R. Burr has succeeded H. W. Whitmore as chief engineer of Kold-Hold Mfg. Co., Lansing, Mich.

♦

James de Kiep, who previously had been manager, alternating-current motor engineering department, Westinghouse Electric Corp., recently became chief engineer in charge of electrical and mechanical design and development, Electric Machinery Mfg. Co., Minneapolis.

♦

Dr. J. T. Rettaliata, manager of research and gas turbine development for Allis-Chalmers Mfg. Co., has recently been named chairman of the mechanical engineering department at Illinois Institute of Technology.

♦

H. E. Simi, bus engineer, has joined the staff of Kenworth Motor Truck Corp., Seattle, to take charge of bus engineering and production. Mr. Simi was chief engineer, Twin Coach Co., Kent, O., for sixteen years, and for the past two years has been with the Timken-Detroit Axle Co., Detroit.

♦

Raymond A. Cole, an authority on precision grinding machinery, has been elected vice president of Pope Machinery Corp., Haverhill, Mass. He previously was experimental engineer in charge of grinding machine research and development, grinding machine division, Norton Co., Worcester, Mass.

♦

Esterly Chase Page, well known in radio engineering and until recently a Lieutenant Colonel in the U. S. Army Signal Corps, has joined the Mutual Network in the newly created post of engineering director.

♦

F. J. Van Poppelen of Fairfield, Conn., has been appointed vice president of Salem Engineering Co. During the past eleven years Mr. Van Poppelen has filled various executive positions at Remington Arms Co., the last several years of which he served as chief engineer of its military division.

♦

F. J. Walls of International Nickel Co., Detroit, has been elected president of the American Foundrymen's Association, while S. V. Wood of Minneapolis Electric Steel Castings Co., Minneapolis, was named vice president.

♦

Dr. Sanford A. Moss, consulting engineer with General Electric Co., Lynn, Mass. River Works, has been awarded the Holley Medal for 1945 by the American Society of Mechanical Engineers. Dr. Moss, a pioneer in aircraft superchargers and the famous turbosuperchargers largely responsible for increased range, speed, and altitude of modern aircraft, received his citation for his "many ... butions over a long period of years to the develop... centrifugal compressors, particularly as related ... highly successful application of turbo-superchargers ... ternal combustion engines in the field of aeronautic...

♦

John G. Wood has been appointed chief engineer ... Chevrolet Motor Division of General Motors Cor... ward H. Kelley is the new assistant chief engineer.

They Say--

"In the explosion of the atomic bomb on Japan we ... evidence that atomic energy in tremendous quantities ... be released and controlled at least to the extent of ca... the release to occur at a desired time . . . It is prob... that as the development is carried along, we will find ... and means of controlling and using this form of en... as a source of heat for direct use, and perhaps for sp... purposes. In addition to the many technical prob... which must be solved before such an application w... be at all feasible, there is also the question as to wh... such peacetime use will be practical from the econ... standpoint."—*Charles E. Wilson*

♦

"Instead of trying to aid industrial research to be ... the society which has created it, it seems inherently hu... for many people to do their utmost to obstruct it."—... *Thomas Midgley Jr.*

♦

"There can never be too much fundamental resea... which should be a major activity in our universities ... aside from its laying the foundation for new technol... and new industries, it supplies the only adequate kin... training for research men for all the fields where they ... needed."—*Dr. Irving Langmuir*

♦

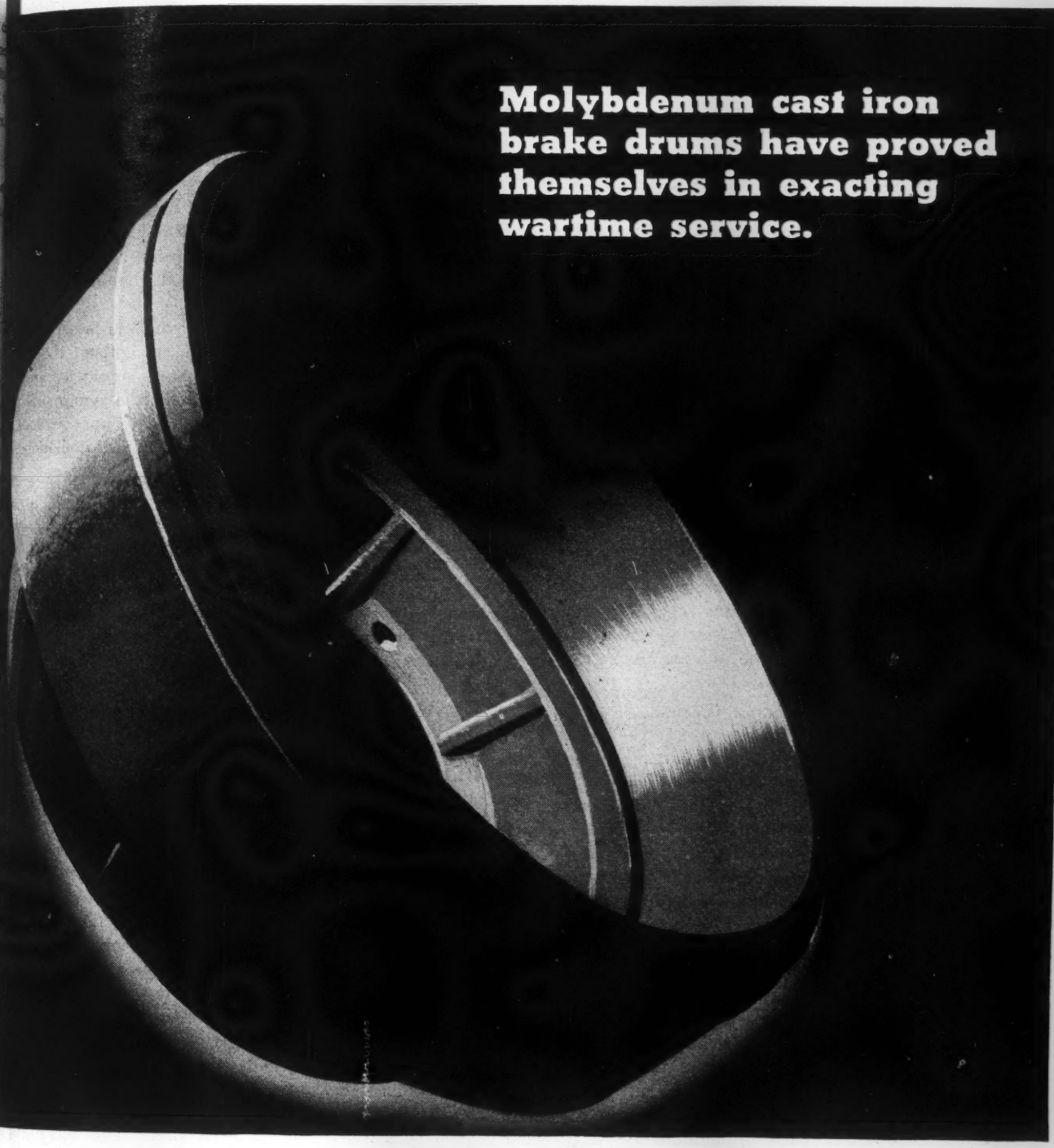
"If necessity is the mother of invention, intuition ... father. Education stressing basic principles and not ... rized formulas would permit a fresher approach to p... lems and would thereby facilitate invention."—D... *Dunlap Smith*

♦

"I am profoundly convinced—and I believe many of ... business associates agree—that technological progress, ... an honest day's work, are the only way in which we ... achieve a vigorous economy and full employment."—... *C. Ingersoll*

♦

"It will be for our scientists and engineers to give us ... technical equipment, embodying the best scientific achie... ments, which will enable our great nation, in co-operati... with the other peace-loving nations, to carry out ... mission . . . . The inventive genius of scientists and ... gineers, having helped to free the world from fear, ... will be called upon to help create a world free fo... want . . ."—*Edward R. Stettinius Jr.*



Molybdenum cast iron brake drums have proved themselves in exacting wartime service.

CLIMAX FURNISHES AUTHORITATIVE ENGINEERING DATA ON MOLYBDENUM APPLICATIONS.

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Climax Molybdenum Company

500 Fifth Ave. • New York City

MOLY

Electric Control Provides Accurate Response

(*Continued from Page* 134)

handwheel on the gunner's manipulation of the latter.

The flange spur gear (*Fig.* 3) is attached to the shaft of a bevel pinion which drives the lower disk of the differential. The upper differential disk is driven in a direction opposite that of the lower disk by a 20 to 1 worm gear reduction from the horizontal power worm coaxial with the handwheel axis. A differential spider supporting three equally spaced rollers is positioned between the two disks by being centered on the tapered portion of a vertical shaft in the differential assembly. The worm gear driving the upper disk is floated on the upper large diameter portion of the vertical differential shaft, while the lower disk and its bevel drive gear are floated on its small diameter lower end. The single vertical shaft of the differential is driven by the roller spider through frictional engagement between the tapered bore of the spider and the matching taper on the shaft. The lower small diameter end of the differential output shaft projects through a double oil seal into the space that houses the control Silverstats and anti-hunting gyroscope. The means for moving the gyro and for deflecting the control Silverstats are attached to this projecting lower end of the differential shaft.

How the Control Functions

Sequence of operations in the functioning of the differential and the follow-up mechanism is as follows. Rotation of the control handwheel by the gunner causes the lower disk of the differential to be turned through a proportional but reduced angle, as determined by the spur and bevel gear reduction ratios. Rotation of the lower disk in turn causes the contacting differential rollers to roll upon the initially stationary upper disk, thus giving an angular displacement to the roller spider equal to half the displacement of the lower disk. The spider drives the vertical shaft of the differential through the tapered clutch and causes a deflection of the gyro and of the Silverstat. The resulting excitation of the generator field yields an output armature voltage which is applied to the traverse motor and causes it to drive the turret.

The horizontal 20 to 1 worm of the turret drive also simultaneously drives the differential worm gear which rotates the upper differential disk in the opposite direction from the initial rotation of the lower disk. This causes the differential rollers to roll back to their starting position, and when this has been reached, the Silverstat deflection is again at neutral and the drive motor and turret come to a stop. Thus the turret is positionally tied to the control handwheel by the differential and rotates in synchronism with the handwheel as if it were in effect geared to it. Attempts to drive the handwheel faster than the drive motor can follow, or to rotate the handwheel with the control de-energized, will result merely in slippage at the spider tapered clutch. This friction clutch is necessary to protect the control shaft from being driven beyond its stops and to prevent sliding of the differential disks and rollers under these extreme conditions of lack of synchronism.

Function of the Silverstat in the control system is shown in the wiring diagram of *Fig.* 5. *Fig.* 3 shows the relati of the Silverstat to the other components of the drive. T Silverstat assembly consists of two 19-leaf stacks of posite hand clamped in a single mounting plate. The sulated actuating pushers are attached to and guided flat bronze springs clamped together with the conta stack. A flat metal spacer attached to the gyro mot frame is interposed between the actuating buttons a converts the differential shaft and gyro deflection to a pr portional deflection at the Silverstat leaves. The Silve stat resistors are mounted on the reverse side of the mou ing plate and project upward into the housing around t gyro motor.

Function of the anti-hunting gyro is to impart a sup rior stability to the positional control without the nec sity for a compromising reduction in sensitivity and a curacy of regulation. More precisely, the gyro makes p sible a higher positional stiffness in the control without curring instability in the form of sustained oscillations.

Mechanical and Electrical Stiffness Compared

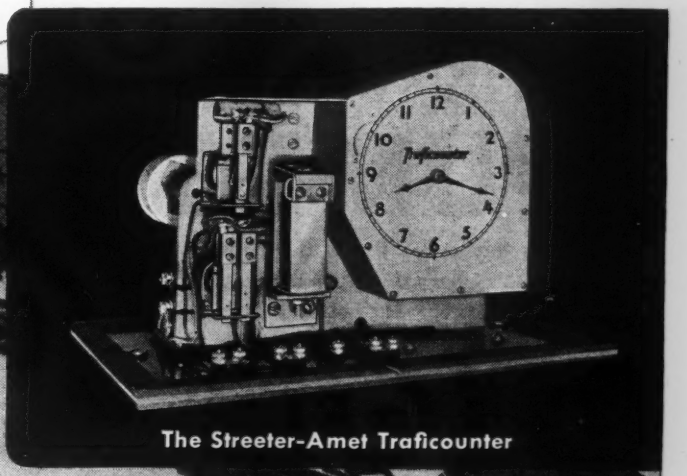
The concept of "stiffness" in a position regulator is principle analogous to the stiffness of a spring or the t sional stiffness of a shaft in a purely mechanical syste In this case the torques urging the turret into synchroni with the control handwheel are proportional to the tw of the handwheel relative to the turret, just as the ela torque of a shaft is proportional to the angle of twist b tween its ends. And just as in a mechanical system stiffer a shaft is the more accurately does one end foll the other in spite of friction and load, so in this elec drive does high regulator stiffness connote ability to eff synchronism between control handwheel and turret w a correspondingly small angle of lag. However, in t case of the electrically derived torques of the turret dri the "spring" restoring torques forcing the turret to mo into coincidence with the handwheel motion differ fr a pure mechanical spring in one all-important respe They are delayed by the inductance of the generator fi and armature, which prevents an instantaneous change current in the circuits upon a change in the Silverstat r sistance due to rotation of the differential shaft. The eff of these time lags in the development of corrective torq is to reduce the system stability by causing the delay positioning torque to have a component in phase with t velocity of free oscillation of the system and thus to supp the energy for maintenance of the oscillation.

Time lags in the synchronizing torques of the trave drive can be compensated for, however, by making t control respond to the time rate of change of error as w as to the displacement error itself between the cont handwheel motion and the turret motion. Such a veloc response has the effect of advancing the phase of the c rective torque to make up for the angular phase lag d to time delays in the control. In the case at hand, t function of the anti-hunting gyro is to produce a co pensatory deflection of the Silverstat proportional to angular velocity of the differential output shaft, this flection to be superposed on (i.e., algebraically added the Silverstat deflection due to angular displacement the differential shaft.

Referring to *Fig.* 3, the gyro assembly of driving m

relays IN THE TRAFICOUNTER

The Streeter-Amet Traficounter tabs 900 or more overlapping cars per minute at split second contact. As car wheels hit a pneumatic tube stretched across traffic lanes the compression closes an electrical contact on a diaphragm, operating a Guardian relay. The relay responds to every impulse but the Traficounter registers only every other impulse to compensate for rear wheel contact.



The Streeter-Amet Traficounter

How *Relays* BY GUARDIAN Count 900 or More Cars per Minute

A grueling job . . . faithfully responding to 1800 or more impulses per minute, hour after hour in rain, heat, and cold the year 'round. For this job Streeter-Amet engineers use Guardian's 6 volt d-c relay, Series 125.

Here is an example of an application that ordinarily calls for a specially built relay. Yet Streeter-Amet finds Guardian's standard relays good enough, dependable enough, and fast enough to do their special job. They save money by buying a standard unit. They get quicker delivery. And they have the comforting knowledge that replacements parts are immediately available if and when needed.

If your application appears to be a "special" it may pay you to look over Guardian's standard relays first. And write us. Guardian engineers will recommend the relay most suitable for your application. If a "special" is really needed they'll help you design it economically.

Series 125 d.c. relay

Also—iron clad and laminated solenoids, stepping relays, magnetic contactors, electric counters, snap and blade switches.

GUARDIAN ELECTRIC

1601-K W. WALNUT STREET CHICAGO 12, ILLINOIS

A COMPLETE LINE OF RELAYS SERVING AMERICAN INDUSTRY

WHEN DEPENDABLE MACHINES & PROCESSING EQUIPMENT NEED PUMPS

Be sure they're

DEPENDABLE PUMPS

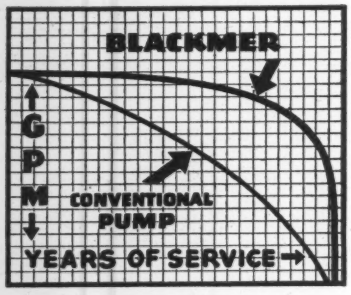
Write for Bulletin No. 306, Facts about Rotary Pumps, and Bulletin No. 302, Pump Engineering Data, which explains why

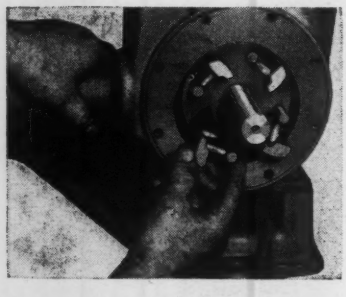
BLACKMER ROTARIES

are *SELF-ADJUSTING FOR WEAR*

SUSTAINED CAPACITY

20 years of service is not unusual for a Blackmer pump.





BUCKET DESIGN

(Swinging vane principle)

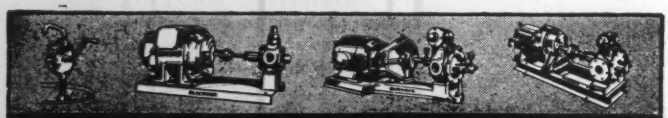
When the "buckets" finally wear out, a 20-minute replacement job restores the pump to normal capacity.

BLACKMER PUMP COMPANY

1970 Century Avenue — Grand Rapids 9, Michigan

POWER PUMPS • *HAND PUMPS* • *STRAINERS*

Capacities to 750 GPM — Pressures to 500 psi



BLACKMER Rotary PUMPS

"BUCKET DESIGN"—SELF-ADJUSTING FOR WEAR

and flywheel is mounted in a forked bracket which is floated on ball bearings on the lower end of the differential output shaft. Pivot pins in the ends of the bracket fork fit into ball bearings in the motor frame to form a horizontal precession axis for the gyro. Precession of the gyro about this axis is restrained by a pair of opposed centering springs hooked over an anchor piece projecting from the main fork and adjustable as to length and tension by means of the attaching screws on plates extending from the gyro frame. A metal spacer projecting below the gyro frame fits between the two insulated deflecting push rods of the Silverstat and moves them as the spacer is moved laterally by the motion of the gyro frame. This actuating spacer is mounted in the plane of the intersecting axes of the precession pivots and of the vertical differential shaft, but contacts the Silverstat push rods at a point off-center from the vertical differential shaft axis. Hence the spacer and the contacting Silverstat push rods are given a deflection due to both the rotation of the vertical differential shaft and to the precession of the gyro about the horizontal pivot axis. The component deflections are combined at the spacer into a resultant deflection equal to the vector sum of the components, which in this case is also equal to their algebraic sum.

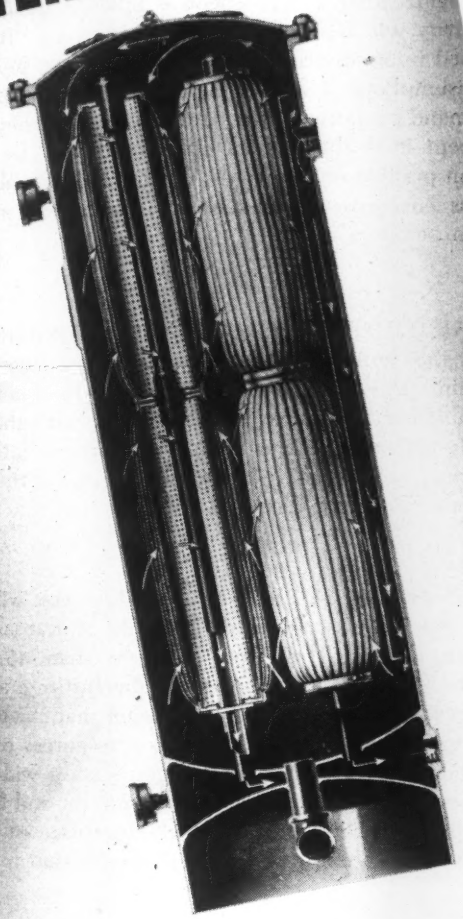
Gyro Responds to Error Velocity

In performing its anti-hunting function the gyro responds to the angular error velocity between control handwheel and follower turret. When the control handwheel is stationary the gyro responds of course only to the turret angular velocity and may be said then to anticipate impending changes in the angular displacement of the turret only. At the start of a control motion, when the turret is stationary and the control handwheel just begins to turn, the gyro responds to the input control motion to give an anticipatory change in the Silverstat deflection and thus to produce a momentary surge of torque from the turret drive motor that is helpful in breaking away the turret against its static friction. The angular error between the handwheel and turret required to initiate motion of the latter is thus appreciably reduced.

A high-accuracy positional control such as is described here is capable of instability in the form of self-excited hunting if necessary measures are not taken for its avoidance through proper regulator design. The correct proportioning of the various control elements, such as the various gear ratios, the allowable Silverstat deflection for a given handwheel rotation and the design constants of the gyroscope, must all be based on stability criteria derived from the equation of motion of the system.

Performance of the turret drive verified the behavior predicted by analysis. The turret followed the control smoothly with rapid decay of transient oscillations. The high regulator stiffness limited the angle of lag between the handwheel and turret to three-tenths of a degree at a turret load equal to the rated load of the motor. This lag angle was so negligibly small for the usual case of steady tracking with no acceleration or gravity unbalance load that the turret seemed to be rigidly geared to the control handwheel. A force of one pound on the handle of the control handwheel was sufficient to move a heavily armored turret weighing twelve thousand pounds.

BRIGGS COOLANT FILTERS PROVIDE . . .



CLOSER TOLERANCES--

BETTER SURFACE FINISH--

REDUCTION OF REJECTS--

LONGER COOLANT LIFE--

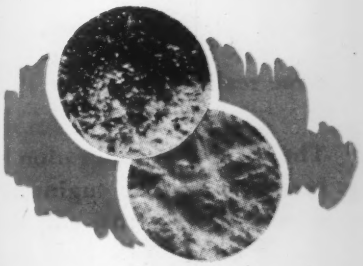
FEWER TOOL OR WHEEL DRESSINGS--

n every shop where Briggs Coolant Filters have been installed, they have roved that effective coolant filtration pays dividends . . . the dividends you ant in your shop.

o wonder *Briggs Filters do a better job*—they are designed especially for ltration of coolants! The unique Z-fold refill is capable of removing even he smallest particle of grit.

riggs Coolant Filters are available for capacities ranging from 3 GPM to 00 GPM—for installation on unit machines or in central systems.

earn why and how Briggs Coolant Filters do a better job of coolant filtration. he Briggs distributor nearest you can tell you. Look him up—he's listed n the "Filters" section of your classified telephone directory, or write direct to:



BEFORE and AFTER

At left is shown dirt deposit on filter paper before filtration—at right, note absence of dirt after coolant passed through a Briggs Coolant Filter.

Briggs

PIONEERS IN MODERN OIL FILTRATION

BRIGGS CLARIFIER CO.

General Offices, Washington 7, D.C.

If You Think

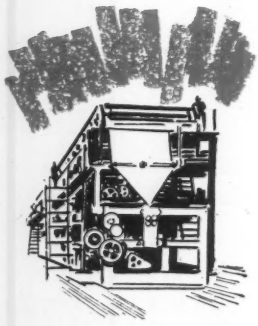
YOU HAVE A TOUGH MOTOR PROBLEM-

● ***LOOK AT THESE . . . LICKED BY STAR!***

Your toughest motor problem may be something Star has been up against before. Star engineers have met, and mastered, plenty of "stumpers" – applying the top-flight resourcefulness and ingenuity that distinguishes their approach to any problem. Here are two in the "can't be done" class that Star engineers took in stride . . .

A SUBMERSIBLE PUMP that has helped save many a Navy Ship required a motor – compact in the extreme . . . powerful beyond its size . . . efficient and reliable in underwater operation. Star engineers designed it. And, not one failure in service has been reported!

A PRINTING PLANT MACHINE was developed to perform "miracles" of production. But its success depended on split-second stopping and starting, everytime. Star engineers applied a Star Brakemotor to the machine, and the "miracles" became realities!



The variety of application problems which have been met by Star engineers covers almost every type of product that employs motor power of ⅛ HP or more. Talk over your requirements with these resourceful specialists. Star Electric Motor Co., 200 Bloomfield Avenue, Bloomfield, N. J.

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

Transition Briefs

IN A RECENT STATEMENT, Alfred P. Sloan Jr., cha man of General Motors said, "It is most important recognize that the prospective upward trend of busine activity will be largely synthetic in origin. It will not based upon an economic balance between production a consumption. It will be the result of a backlog of potenti demand supported by a backlog of purchasing power. T accept it as the pattern of the economy for the long term position ahead would be unsound. To plan any bu ness enterprise upon such an assumption would be f from realistic."

AUTOMOTIVE ENGINEERS are converting to rea ties the desires of wounded veterans to drive automobi again. Prosthetic devices and simple mechanical aids w enable even amputees to operate cars and light trucks sk fully and safely. This engineering project with its huma itarian undertones is being carried on by the War Eng neering Board of the SAE.

MANUFACTURERS in the middle west will be offer by the Midwest Research Institute of Kansas City, co plete working drawings on more than 45,000 pate seized from enemy countries. The Institute also will co duct research on private projects for manufacturers as w as research of its own to develop resources of the regi Establishment of a laboratory on such a wide scope pr vides facilities to the small manufacturer and business m whose firm cannot afford to conduct its own research l must keep abreast of the keen competition to come.

SPEEDY CONVERSION from war to peace is bei facilitated by 114 contract termination teams for rap settlement of 10,000 contracts for Air Force equipme The Air Force is determined that it shall not impede i dustry in returning to the production of refrigerato radios, automobiles and other mechanical appliances d signed for better peacetime living.

RECENTLY DEVELOPED high-temperature and hig stress resisting alloys which are playing a vital part in je propulsion and gas-turbine engines may have many po war applications not necessarily confined to aviation. T meet the requirements for turbine buckets in jet propu sion motors, alloys have been developed to withsta stresses of 15,000 psi at temperatures up to 1500 F. Th must be corrosion resistant, creep resistant, capable of b ing processed into desired shapes and able to withsta severe operating conditions. In peacetime applicatio the cost of these materials is important but it is reasonab to believe that costs will become considerably lower th at present. As they are reduced, broader applications w be economical, allowing utilization of higher temperatu in internal combustion engines, steam equipment, etc., sulting in improved performance.

To Men Who Know Motors

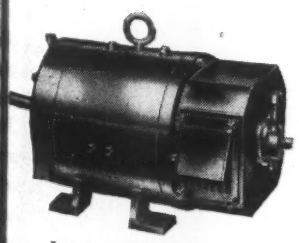
. . . we could end our message here!

To men who know motors, a picture like this is worth the proverbial ten thousand words. It speaks with convincing eloquence of craftsmanship to which any motor builder could point with pride.

If you visit Star's modern plant, you'll see scores of examples of the same painstaking craftsmanship that pays off in outstanding performance for Star customers.

Star not only builds motors well, but also takes leadership in design. Star pioneered ball bearing motors . . . led in welded steel construction . . . developed the famed Star Built-in Magnetic Disc Brake for motors . . . pioneered in the field of gear-motors.

Whether you need special or standard motors, 1/8 to 200 H.P., it will pay to learn why so many critical buyers specify "Star". Some standard motors are ready for early delivery. Star Electric Motors Co., 200 Bloomfield Avenue, Bloomfield, N. J.



Integral HP Motor for Direct Current

ARMY-NAVY "E"

STAR MOTORS

POWER PACKAGED AS YOU NEED IT

BUSINESS AND SALES BRIEFS

SUCCEEDING Ray F. Landis is Glenn Saythe as manager of the Minneapolis branch of Ahlberg Bearing Co., Chicago. Mr. Saythe has been connected with this branch since 1929 in sales and service capacities.

♦

Establishment of a branch plant at Jefferson and Lawton St., Fall River, Mass., has been announced by Harvill Corp., Los Angeles. Handling all types of die casting, finishing and machining, the new plant will be operated by the Harvill New England Corp., a wholly owned subsidiary.

♦

Tyson Bearing Corp. of Massillon, O., has named Borg-Warner International Corp., Chicago, as sales representative in all export markets except Canada and Alaska.

♦

Connected with the company since 1927, F. A. Wright has been appointed assistant general sales manager of Cutler-Hammer Inc., Milwaukee. Fred W. Gilchrist, associated with the company for more than twenty-two years, has been named manager of the branch office in Indianapolis.

Election of Oscar C. Schmitt as president to succeed Stuart Symington has been announced by The Emerson Elec Mfg. Co., St. Louis. Among other capacities Mr. Schmitt served as vice president in charge of general sales, and recently as executive vice president.

♦

Three appointments have been made by United Chrom Inc. These are: Richard O. Leongard as president, Theodore G. Coyle and Hugh D. McLeese as vice presid Mr. Coyle will continue as technical director, and Mr. McL as general sales manager.

♦

According to a recent announcement by Westinghouse E tric Corp., an $11,500,000 expansion program has been pla to increase overall production fifty per cent in the Ele Appliance Division plants at Mansfield, O., and East Spri field, Mass.

♦

Made known recently by B. F. Goodrich Chemical Cleveland, is the appointment of Sam L. Brous as sales m ager of a new division for the promotion and sale of the setting resins.

♦

With headquarters at the Ewart plant in Indianapolis, I Fellinger has been named by Link-Belt Co. as sales mana power transmission machinery, while H. F. R. Weber has b appointed divisional sales manager, silent chain drives. S through distributors will be under the supervision of the lowing: F. A. Hurd, divisional sales manager, industrial

PRESSURE GENERATORS FOR OIL HYDRAULIC CIRCUITS
HYDRO-POWER Radial Pumps have established the reputation for dependable service. All pump members are of sturdy proportions, finished with very close tolerances. Minimum operating clearances are maintained for high hydraulic efficiency. This is practical, due to exclusive HYDRO-POWER design features, which assure precise relationship between the vital working parts. Write today for engineering bulletin 411. Find out why HYDRO-POWER Radial Pumps will best solve your hydraulic pressure generating problems.
There is a HYDRO-POWER Radial Pump for every hydraulic requirement, regardless of size. HYDRO-POWER Radial Pumps are built with output capacities from 1½ to 185 gallons per minute; operating pressures to 2000 lbs. per sq. inch.
hydro power
HYDRO-POWER
HYDRAULIC PUMPS AND CONTROLS - VALVES - CYLINDER AND RAM ASSEMBLIES - POWER UNITS - SYSTEMS - SPECIAL HYDRAULIC EQUIPMENT
HYDRO-POWER SYSTEMS, INC.
Mount Gilead, Ohio, U.S.A.

NICKEL ALLOY STEELS

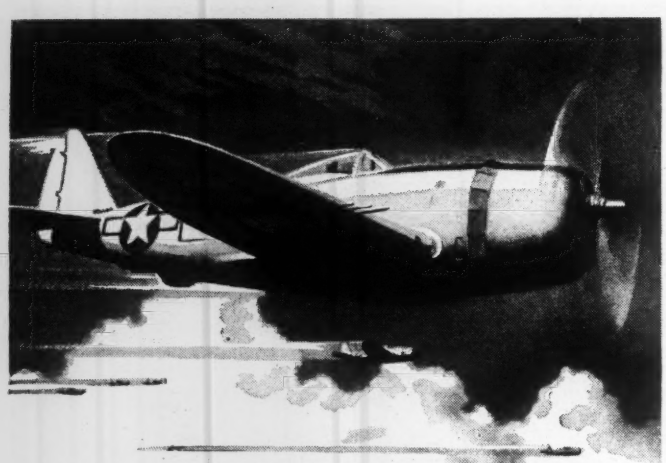
Provide Essential Dependability

These Nickel steel parts for aircraft engines meet the rigid requirements and specifications of the Army Air Forces.

Turned out by the thousands by American Safety Razor Corporation, they satisfy the engine builders' demands for high mechanical properties, minimum distortion after heat treatment, close tolerances and thorough reliability in service.

We invite consultation on the use of Nickel or Nickel alloys in your products or equipment.

THE INTERNATIONAL NICKEL COMPANY, INC. 67 WALL STREET NEW YORK 5, N. Y.

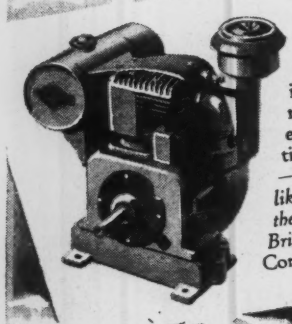


ARMY AIR FORCES AWARD BRIGGS & STRATTON "Approved" QUALITY CONTROL RATING

For over two years Briggs & Stratton has produced the General Electric high-tension magnetos used on the 18-cyl. Pratt & Whitney 2000 h. p. engines powering high-flying fighters, bombers and transport planes.

In recognition of the high standards of inspection procedures and control in the manufacture of these magnetos, the U. S. Army Air Forces have accorded to Briggs & Stratton the "APPROVED" Quality Control Rating.

Air-Cooled Power 4 CYCLE BRIGGS & STRATTON GASOLINE ENGINES



The ultra-precision construction, close tolerances, and rigid inspections necessary in making these high-tension magnetos is far more exacting than generally used. Yet no special preparations were needed at Briggs & Stratton, — *because for many years, this same watch-like precision has been the outstanding factor in the long life and superior performance of Briggs & Stratton engines!* Briggs & Stratton Corporation, Milwaukee 1, Wisconsin, U.S.A.

tributor sales, Chicago; G. H. Unruh, divisional sales m industrial distributor sales, Philadelphia; and Harry R divisional sales manager, automotive equipment sales, I apolis.

♦

Recently announced by The National Acme Co. is th pointment of Ralph R. Root as sales manager of the Ele Mfg. Division. For the past eight years he has served thi sion in a sales engineering capacity in Ohio and Indiana.

♦

Previously known as Swedlow Aeroplastics Corp., the P Division of Shellmar Products Co. has moved from Gle Calif., to 8990 Atlantic Ave., South Gate, Calif. A New Yor office in the Empire State building has been opened re by the company.

♦

Change of name has been made by Duramold Plastics, South Wabash Ave., Chicago. Henceforth the company w known as Formold Plastics.

♦

Appointment of V. C. Kneese as manager of the Dalla tory branch has been made by General Controls Co., Gle Calif. He will serve users of automatic controls in the he refrigeration, aircraft and industrial fields throughout the n ern half of Texas, Oklahoma and Arkansas.

♦

Wright Engineering Co., 5620 North Meridian St., Ind apolis, has been named by Ward Leonard Electric Co. of M Vernon, N. Y., to serve as sales representative in southern diana, southwestern Ohio and Kentucky.

♦

Opening of a new office in the Empire State building at Fifth Ave., New York, has been announced by Columbia tektosite Co. Inc.

♦

Located at 308 West Washington Ave., a new Chi branch office has been opened by Stow Mfg. Co. of Bingh ton, N. Y. Ralph E. Wimmer has been placed in charge will be assisted by J. P. Dickinson, vice president in charg sales.

♦

Purchase of Makalot Corp., Boston, has been announced cently by Interlake Chemical Corp., Plastics Division, Cl land.

♦

Under the supervision of R. P. Evans, a new warehouse a office at 790 Greenwich St., New York, has been opened by Carpenter Steel Co. of Reading, Pa.

♦

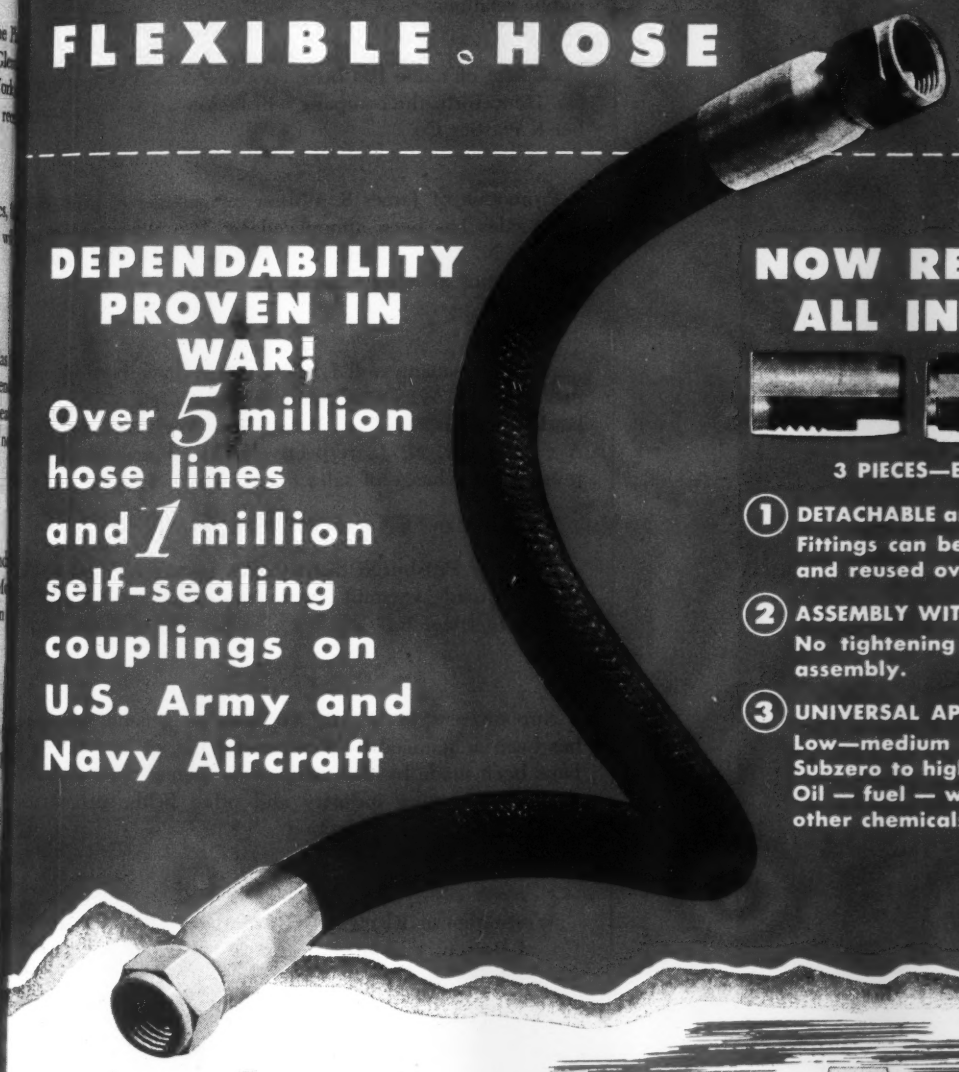
Allen-Bradley Co. of Milwaukee has appointed C. D. Bel Co., 1530 Sixteenth St., Denver, Colo., as district sales rep sentative for the company in the state of Colorado, the p handle of Nebraska, and the southern part of Wyoming.

♦

Election of W. W. Gleeson as president has been annou by L. G. S. Spring Clutch Corp., a wholly owned subsidia Curtiss-Wright Corp. While the present output of the

Aeroquip

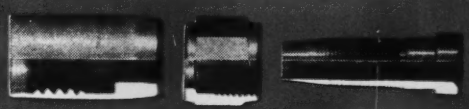
FLEXIBLE HOSE LINES



DEPENDABILITY PROVEN IN WAR!

Over 5 million hose lines and 1 million self-sealing couplings on U.S. Army and Navy Aircraft

NOW READY FOR ALL INDUSTRY



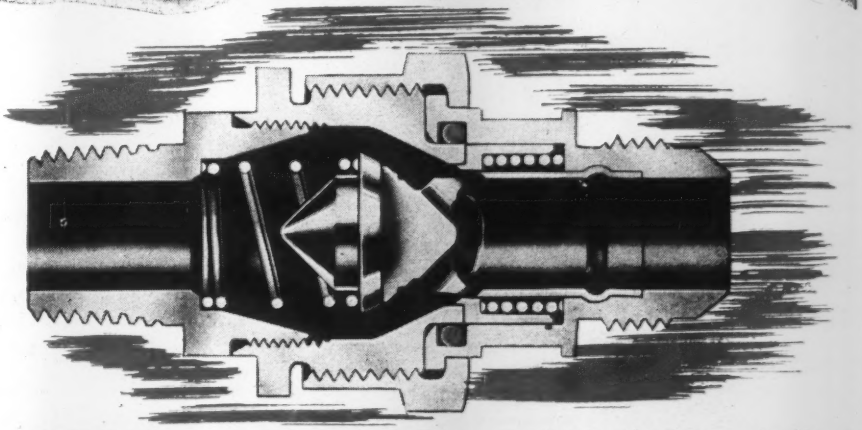
3 PIECES—EACH REPLACEABLE

1. **DETACHABLE and REUSABLE FITTINGS**
   Fittings can be removed from hose and reused over 100 times.
2. **ASSEMBLY WITHOUT SPECIAL TOOLS**
   No tightening or adjustment after assembly.
3. **UNIVERSAL APPLICATION**
   Low—medium and high pressure. Subzero to high temperature. Oil — fuel — water — air and many other chemicals.

Aeroquip

SELF-SEALING COUPLINGS

allow disconnection of liquid carrying lines without loss of fluid and reconnection without inclusion of air.



SALES OFFICES: *Los Angeles 14, California, 1709 W. 8th St.; Houston, Texas, 1104 Commerce Bldg.; Hagerstown, Maryland*

AEROQUIP CORPORATION, JACKSON, MICHIGAN, U.S.A.

sidiary is devoted to spring clutch applications for Army nance equipment, postwar applications include auto transmissions and starters, household appliances such as ing machines, ironers, deep freeze units and stokers, and engines and marine steering devices, farm implements well drills.

◆

Homestead Valve Mfg. Co., Coraopolis, Pa., has appo Don H. Krey as sales manager and Elliott G. Johnson as ant sales manager. In addition to his new appointment Johnson will retain his duties as director of advertisin public relations.

◆

Change of name has been announced by Vulcanized R Co. Henceforth the company will be known as Vulcanized ber & Plastics Co.

◆

Promotion of James S. Wilson to manager of plastics e ment sales has been announced by The Watson-Stillman Roselle, N. J. Previously Mr. Wilson headed the Watson man plastics molding laboratory.

◆

A. G. Bussmann and L. D. Granger have been elected presidents of Wickwire Spencer Metallurgical Corp. and be located at 500 Fifth Ave., New York, and 260 She Ave., Newark, N. J., respectively. Mr. Bussmann is also president in charge of sales for Wickwire Spencer Steel C

◆

Formerly Pittsburgh district sales manager, Lloyd R. Cl has been made assistant general sales manager of Firth-Ste Steel Co.

◆

Appointment of W. D. Turnbull as general sales man has been announced by Kennametal Inc. of Latrobe, Pa. F have been made by the company to increase present activit the metal-working industry and other fields such as min petroleum and wood-working.

◆

Westinghouse Electric Corp. has acquired B. F. Sturte Co. of Boston, a pioneer in the design and manufacture o handling and processing equipment. The newly acquired c pany will be operated as a division of Westinghouse Elec

◆

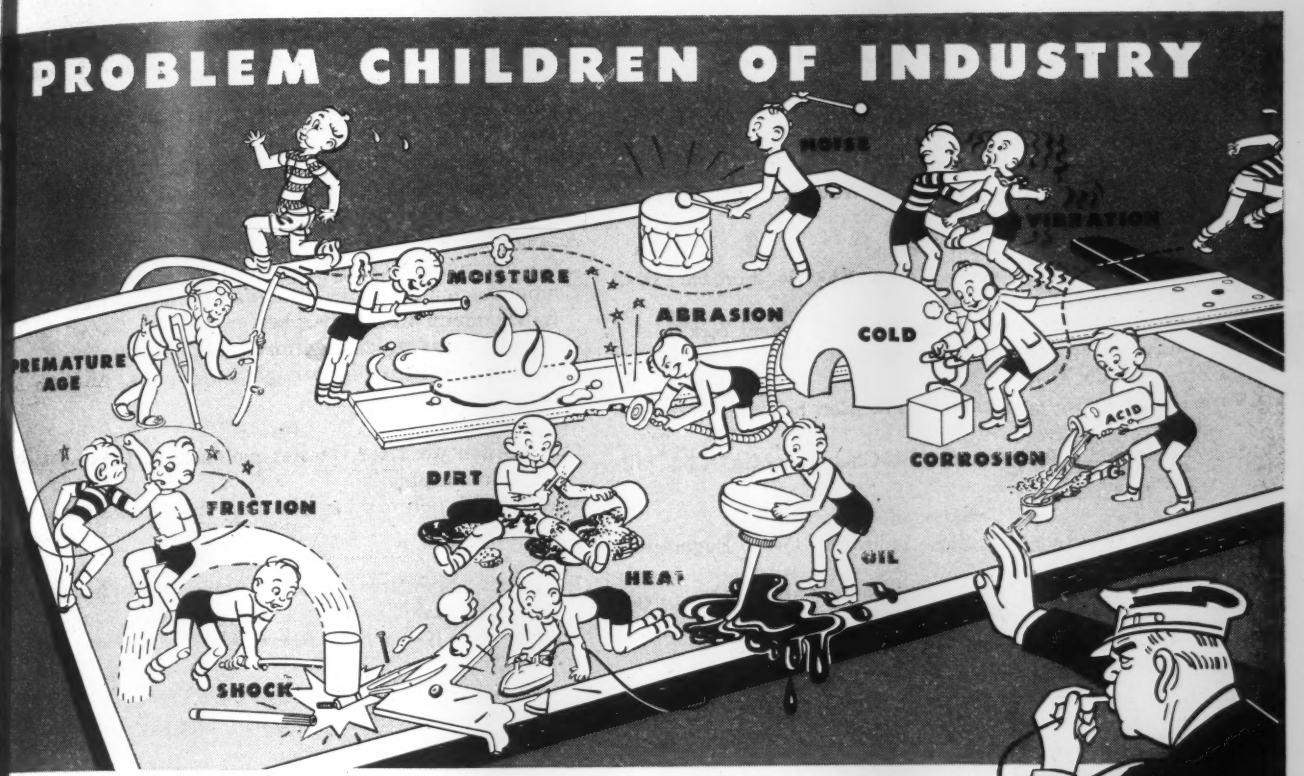
Need for expansion has resulted in the opening of a n Research and Engineering Building by Taylor Fibre Co Norristown, Pa.

◆

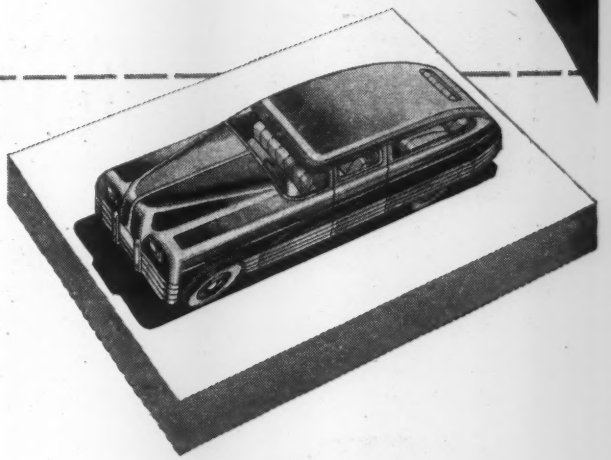
Announcement has been made of the incorporation of C Hunt & Son Co. under the name of C. B. Hunt & Son Inc. new president is N. A. Pedersen of Elkhart, Ind., who rep sented the company in the New York territory for a numbe years. N. C. Hunt, who retired as president, is now treasure the new corporation.

◆

Formation of a new division, to be known as the Cen Alloy Valve Co., has been announced by The Cooper A Foundry Co. of Hillside, N. J. This arrangement will c metallurgical, engineering and manufacturing activities, inc ing casting, heat-treating, machining and testing.



Keep them away from *Your* Postwar PRODUCTS



● Greater control of vibration, shock, friction, abrasion, and many other "problem children of industry" is now possible due to improved methods of compounding, molding, extruding, calendering, coating, and bonding natural and synthetic rubbers.

ORCO engineers are abreast of these technological developments and are prepared to apply them where they are needed the most to improve your company's products.

ORCO'S expanded facilities, new methods, new processes, and a strictly unbiased viewpoint regarding basic materials offer you a hard-to-match source of co-operation in the field of rubber and synthetic rubber.

Your inquiries on specific problems are invited.

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